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Sustainability in Heritage and Urban Planning

Edited by
Lucia Della Spina, Paola Pellegrini, Antonia Russo, Maria Rosa Valluzzi and Angela Viglianisi

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Contents

About the Editors

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She was Visiting Professor at the School of Public Affairs San Diego University (USA); University of Salford, Manchester (UK); Universidade Trás-os-Montes Alto Douro - UTAD (PT); and University of Granada (ES).

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She is the author of over 100 publications and has presented papers at numerous international workshops and conferences. For the quality of scientific production, she has received the following international recognitions: ”Top 2% Scientists of the world 2021”, ”Top 2% Scientists of the world 2020”, and “Best Paper Award -Buildings 2017”.

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Paola is an Associate Professor at one of the main Sino-British universities in China. She holds Bachelor's and Master's degrees in Architecture and a PhD in Urbanism. Before moving to China, she lectured in Italy, Switzerland, Brazil, and the USA, where she was a Visiting Associate in Urban Planning and Design at the Graduate School of Design at Harvard. For more than 15 years, she led several research projects focusing on urban sustainability and heritage, received several research grants, and developed a strong ability to apply for funding from the European Union Programmes. She has extensively published the results of her applied research.

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Antonia Russo

Antonia Russo received a PhD in Information Engineering in 2022. Now, she is working on the adoption of cybersecurity in a multinational company. She has dedicated herself to researching information security, privacy, and social network analysis. In 2021, Antonia was appointed as a Visiting Researcher at the European Space Agency in collaboration with the Radio Navigation Systems and Techniques Section, Directorate of Technology, Engineering and Quality (TEC-ESN). From 2020 to 2022, she co-led the Space Generation Advisory Council's Space and Cybersecurity Project Group.

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Angela Viglianisi received a PhD in Conservation of Architectural and Environmental Heritage, specialization in Project and Program Evaluation (ICAR/22 - Appraisal).

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Preface

In an era marked by unprecedented urbanization and a growing emphasis on sustainability, "Sustainability in Heritage and Urban Planning" emerges as a beacon of knowledge within the overlapping fields of urban development and heritage preservation. The global landscape is rapidly transforming, presenting us with multifaceted challenges that demand innovative solutions capable of harmonizing the preservation of our cultural heritage with the imperative of sustainable urban growth.

The inception of this e-book can be traced back to a profound recognition of the urgent need to comprehensively address these challenges. The endeavor is rooted in the understanding that urban areas are not isolated entities; they are intricate ecosystems interwoven with their cultural heritage. Neglecting this intrinsic relationship jeopardizes not only the cultural legacy of our past but also the environmental viability of our future.

In this context, the volume serves as a pivotal reference for scholars, practitioners, and policymakers seeking a multifaceted understanding of the intricate interplay between sustainability and heritage within the realm of urban planning. Comprising 30 diverse articles penned by esteemed experts in the field, this volume offers a comprehensive exploration of the topic, encompassing the breadth and depth of contemporary research.

Within these pages, we have assembled a remarkable collection of articles, each delving into a distinct facet of the complex relationship between sustainability and heritage in urban planning. These contributions range from the examination of traditional architectural strategies in vernacular housing to the evaluation of urban sustainability along historic routes. They encompass studies on the adaptive reuse of industrial heritage and the cultural significance of local landscapes, among other compelling topics.

All the articles collectively underscore the paramount importance of interdisciplinary research and innovative approaches in confronting the intricate challenges posed by the coexistence of cultural heritage and sustainable urban development. We firmly believe that the insights provided by these articles will invigorate the discourse and empower the formulation of strategies aimed at achieving a harmonious equilibrium, preserving our heritage while nurturing sustainable, vibrant urban spaces for the benefit of generations to come.

Lucia Della Spina, Paola Pellegrini, Antonia Russo, Maria Rosa Valluzzi, and Angela Viglianisi

Editors

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Article

A Prefeasibility Study for the Adaptive Reuse of Cultural Historical Landscapes as Drivers and Enablers of Sustainable Development

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Abstract: The international scientific debate on the growing concern over land consumption has gained prominence in recent years. The awareness of the link between cultural heritage and sustainable development has become increasingly evident, leading to a greater focus on the Adaptive Reuse (AR) of cultural assets as a conscious process of creating new values. This trend has prompted a reflection on urban planning practices and the promotion of AR and valorization policies for heritage, which can contribute to environmental sustainability, social cohesion, and cultural identity, thereby providing fertile ground for innovation and local economic development. However, decisions regarding AR interventions pose significant complexity due to the multiple interests at stake, as well as high costs that discourage investiments. For these reasons, this paper proposes a multi-methodological approach—applied to a project for the AR of a cluster of mountain huts located in the Sila National Park (SNP)—aimed at effectively supporting decisions related to the evaluation of feasibility and economic sustainability of cultural heritage landscapes that have not yet been adequately valorized. This approach was applied to a pilot project of AR, allowing for the discussion of the proposed evaluation methodological framework. The final step involved verifying the economic feasibility and financial sustainability of the methodology based on a Financial Feasibility Plan (FFP) of the proposed of the new destination to 'Rifugio Diffuso' (RD). The assessment aimed to evaluate the intervention's ability to create value, generate a level of profitability that meets private investment expectations, and promote sustainable development of the local economy.

Keywords: cultural historic heritage; circular economy; historic centers; integrated adaptive reuse projects; 'Rifugio Diffuso'

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1. Introduction

The concept of achieving closed cycles [1] is a fundamental principle within the ecological paradigm, but its complete implementation remains unrealized thus far. Addressing the challenges of our time involves adopting observable models from natural systems, offering efficient approaches to management, production, and consumption [2].

The traditional economy, often referred to as the "conventional" economy, has had detrimental effects on cultural landscapes and individual cultural assets/sites. It has caused environmental damage, health issues, and disruptions to social systems, ultimately contributing to high entropy [3,4]. On the contrary, the emerging concept of the Circular Economy (CE) has the potential to enhance cultural heritage and landscapes while simultaneously fostering economic prosperity. This necessitates the development of organizational and entrepreneurial processes that promote symbiotic relationships and generate new bonds. CE not only reduces entropy across various levels but also enhances efficiency and resilience [5]. Additionally, CE is founded upon principles of cooperation, solidarity, co-evolution, and long-term thinking. It relies on the management practices of common goods, which, in turn, require cooperation, collaboration, and coordination among various stakeholders. This approach embraces relational values, intrinsic values, and the co-production of economic values for both use and the market [6].

Considering landscapes and cultural heritage as common goods encourages the formation of a "community of relationships". This community plays a crucial role in determining quality of life while also giving rise to new chains of economic value [7]. To shape a progressive future rooted in a "new humanism" [5] inspirtioin must be found in a journey of modernization that embraces the symbiotic relationship between society and nature: "Noi, il soggettivo ed il collettivo, il soggettivo ed il naturale, riconfigurando i valori della modernità in una prospettiva di 'razionalità relazionale' che rappresenta il fondamento stesso della prospettiva di un nuovo Umanesimo . . . fondato sulla simbiosi società/natura, innanzitutto attraverso la valorizzazione di tutti i 'beni comuni' presenti nel sistema urbano territoriale a partire dal patrimonio culturale, dagli ecosistemi naturali, dalla biodiversità, dal paesaggio, capaci a loro volta di promuovere la decentralizzazione, l'autorganizzazione, l'autogestione" [5]. This involves prioritizing the enrichment of "common goods" [5] within the urban territorial system, including cultural heritage, natural ecosystems, biodiversity, and the landscape. Elevating these assets can foster decentralization, empowering local communities to self-organize and self-manage. This holistic approach promotes sustainability, resilience, and equitable resource distribution, establishing a harmonious coexistence between society and the natural world guided by the principles of a "new humanism" [5].

Embracing this viewpoint entails presenting regeneration initiatives according to the "circular city model" [8–12]. This model embodies an urban economy that emphasizes circularization in production and consumption. It focuses on strategies that aim to alleviate the strain on finite natural resources, reducing their consumption while promoting sustainable practices [8–12]. In this perspective, the awareness of the link between cultural heritage and sustainable development has become increasingly evident, leading to a greater focus on the Adaptive Reuse (AR) of cultural assets as a conscious process of creating new values [13]. This trend has prompted a reflection on urban planning practices and the promotion of AR and valorization policies for heritage, which can contribute to environmental sustainability, social cohesion, and cultural identity, thereby providing fertile ground for innovation and local economic development. However, decisions regarding AD interventions pose significant complexity due to the multiple interests at stake, as well as the high costs that discourage investments [14,15].

Within these decision-making contexts, the objective of the research is to set up a multidisciplinary evaluation model that supports public and private investors in effectively planning underutilized cultural heritage reuse projects. For these reasons, this paper proposes a multi-methodological approach applied to a pilot project for the AR of a cluster of mountain huts located in the Sila National Park (SNP), which is aimed at effectively supporting decisions related to the evaluation of feasibility and economic sustainability of this cultural heritage that has not yet been adequately valorized. This case study application enables a discussion of the proposed evaluation framework and, in the final phase, verifies the economic feasibility and financial sustainability through the Financial Feasibility Plan (FFP) of the proposed of the new destination to the 'Rifugio Diffuso'. In essence, the evaluation aims to assess the intervention's ability to create value, generate a level of profitability that meets private investment expectations, and promote sustainable development of the local economy.

Based on these premises, this paper is organized as follows: after introducing the research objectives in Section 2, a literature analysis on open issues related to project evaluation in the field of cultural heritage is discussed in Section 3. Section 4 presents a case study of cultural heritage reuse for the "Rifugio Diffuso" project, while the proposed methodological framework is described in Section 5. Section 6 illustrates the applications of the case study. Finally, Sections 7 and 8 are dedicated to the results obtained from the application and to the conclusions that highlight the significant role that the proposed methodological framework can play in promoting and supporting the reuse of cultural heritage landscapes, respectively.

2. Objectives

In the outlined perspective, an awareness of the connection between cultural heritage and sustainable development has become increasingly evident, leading to a greater focus on the reuse of cultural assets as a conscious process of creating new values. This trend has prompted a reflection on urban practices and the promotion of policies for the reuse and enhancement of heritage, which can contribute to environmental sustainability, social cohesion, and cultural identity, thus providing a fertile ground for innovation and local economic development. However, decisions regarding reuse interventions pose significant complexities due to the multiple interests at stake as well as the high costs that discourage investments. In the dynamic context described, the adoption of integrated methodologies plays a strategic role in addressing every phase of the decision-making process, from its initial conception to the selection of the most suitable scenario, taking into account the context and the stakeholders involved.

This study develops a multidisciplinary evaluation model that supports the decision-making process of both public and private investors for the effective planning of underutilized cultural heritage reuse projects. Given market uncertainty and the ongoing financial crisis, it has become crucial to define effective evaluation tools that identify the optimal utilization of limited economic resources and develop sustainable strategies at the local level, maximizing societal and territorial benefits while minimizing costs [15].

To illustrate this methodology, a pilot project has been chosen as a case study for the redevelopment and reuse of a group of shelters located in the Sila National Park (PNS) in Italy. As in many regeneration and valorization processes involving cultural assets, key decision-makers are primarily represented by the Public Administration, political decision-makers, public entities, communities, associations, businesses, and investors. These actors work with a global and sustainable vision for the transformation of the park, which includes environmental protection, social cooperation, technological progress, and cultural preservation.

Although the individual frameworks and methodologies used in this research are already known, their combination in a multi-level, multi-scale, and multi-stakeholder approach represents an innovative element. This combination of conceptual frameworks and methodologies allows for integrated and informed decision-making, enabling a comprehensive exploration of strategic urban issues. Their implications can be further explored through a rich knowledge framework developed by analyzing the social, infrastructural, and environmental layout of the case study under consideration. The proposed integrated method can be seen as a systematic scheme that supports both research and practice in the scenario analysis, addressing the complexity and uncertainty associated with defining urban strategies [16]. Furthermore, this approach ensures that the knowledge development is relevant and credible, providing a solid foundation for the decision-making process.

In conclusion, the adoption of integrated methodologies represents a key to addressing the challenge of valorizing cultural heritage, aimed at effectively supporting decisions related to the assessment of feasibility and economic sustainability of underutilized cultural assets. Through the application of a multi-level, multi-scale, and multi-stakeholder approach, decision-makers can make informed decisions, supported by a solid knowledge base and oriented towards promoting sustainable development for the benefit of the local economy.

3. Literature Review

The scarcity of resources, rapid urbanization, and climate change pose threats to ecosystems and human well-being [1,2]. To address these challenges, sustainable development [3] and the transition to a CE are considered crucial [4,5]. A CE involves production and consumption processes that minimize environmental impacts and waste generation, extending the lifespan of products and materials while reducing consumption and waste [6]. The built environment, which consumes a significant amount of resources and produces carbon dioxide emissions, is a key sector to focus on [4,8].

Cultural heritage, a driving force for sustainable development and urban livability, consists of non-renewable resources that express the values, knowledge, and traditions of people [17,18]. The management of cultural heritage has evolved to be understood as "change management", involving a variety of stakeholders and disciplines [19–23]. The Adaptive Reuse (AR) of cultural heritage, which preserves the heritage by providing a new function to the site/building, extends the life cycle of the heritage and can implement circular models in its management [13,24–29]. This approach contributes to achieving sustainable development and circular cities [8–13,29,30].

AR, a central element of the CE concept which is in line with sustainable architecture [28], has emerged as a rapidly growing practice that promotes the three pillars of sustainability [21]. In fact, it offers numerous social, environmental, and economic benefits.

From a social perspective, the process of conserving and adaptively reusing built heritage requires widespread awareness of its material and immaterial values [21,27,29] within society. Governments, tourism businesses, cultural associations, and individuals must be actively involved in this process, and informative campaigns can increase the social awareness necessary for a transition towards a CE model [31,32]. Additionally, it is essential for decision-makers to invest more in education about heritage management and the values of historic buildings for younger generations [33]. The knowledge and collaboration of all stakeholders are crucial for the application of a CE to build heritage. Only through the engagement and cooperation of all parties involved will it be possible to successfully implement adaptive reuse projects in the tourism sector.

The restoration of cultural and historical heritage (such as ancient buildings, historic villages, industrial complexes, etc.) is not only a crucial model for envisioning tourism development within a circular economic framework, but it also holds significant value for the local community. It becomes a source of pride that effectively protects the heritage. As a result, the local community benefits from an improved living environment, the quality of life in a particular area is enhanced, and regional development is facilitated. Furthermore, Foster and Saleh (2021) [34] state that "culture and buildings of cultural heritage are established drivers of socioeconomic development, urban landscape, and identity strategies". In this regard, positive mutual cooperation and communication among stakeholders involved in restoration are necessary, as development objectives can only be achieved through the engagement and cooperation of all stakeholders. The recovery of cultural and historical heritage, including ancient buildings, historic villages, and industrial complexes, is not only a crucial model for tourism development but also holds value for the local community. The community itself protects the heritage it takes pride in, resulting in an improved living environment and a better quality of life in the surrounding area, thereby promoting regional development. According to Foster and Saleh (2021) [34], "culture and cultural heritage are established drivers of socioeconomic development, urban landscape, and identity strategies". In this perspective, mutual cooperation and positive communication among stakeholders involved in restoration are necessary, as development objectives can only be achieved through the engagement and cooperation of all stakeholders.

Regarding environmental sustainability, reuse primarily results in lower consumption of energy and new materials, thus reducing emissions and land sealing [35–37]. Finally, from an economic perspective, two main advantages are evident: the cost-effectiveness of reuse compared to the demolition and construction of a new building [38–42], and the positive impact it has on the property value of the building itself and surrounding properties, generating social and economic flows [43]. The development of heritage tourism involves not only identifying, managing, and protecting the value of the heritage itself but also engaging local communities through economic and social benefits, ensuring the security of financial resources and promoting the marketing and promotion of the tourism destination [44]. Heritage tourism contributes to the economic sustainability of the tourism sector by increasing visitor numbers and the income generated by tourists as well as stimulating positive effects across various sectors and creating employment opportunities. In this perspective, cultural heritage must be considered as a resource for present and future generations, to be utilized in accordance with the principles of the CE to achieve sustainable development goals [44].

New or underutilized existing buildings, if kept efficient, can be reused for over a century, adapted, and reconfigured for new purposes and functions, contributing to the development of a prosperous and resilient built environment. Therefore, the importance of the AR approach for economic growth, social well-being, and environmental conservation is widely recognized. The reuse of underutilized or abandoned heritage provides new opportunities for these assets, decoupling growth from resource consumption [45,46].

Similar to new buildings, AR projects have a lifecycle consisting of various stages, including planning, design, construction, management, and maintenance [13,38,45,46]. These projects involve different public and private stakeholders. Therefore, a standardized methodology is necessary that considers all perspectives and helps "speak the same language" [47]. Scientific studies demonstrate that assessment tools such as sustainability protocols are relevant for this analysis, considering the importance of responsible approaches in the built environment to develop sustainability assessment tools [6,17,19,21,24,25,27,28,38,42,45,48].

In this context, research in the field of decision-making assessments has increasingly highlighted the importance of adopting and promoting responsible practices that carefully consider the implications of cultural heritage reuse. The crucial challenge lies in finding suitable evaluation methodologies that ensure feasibility and sustainability while preserving the integrity of the heritage [49–51] without compromising its authenticity and value while also enabling effective and mindful management. Achieving an appropriate balance between development and conservation is a complex challenge, especially in a country like Italy, which is characterized by the highest density and distribution of cultural heritage in the world.

In this perspective, it becomes crucial to promote a culture of assessment that carefully considers all aspects, including financial considerations, while placing special emphasis on conservation. Cultural heritage is a valuable asset that needs to be safeguarded for future generations, and this requires a responsible and mindful approach to the implications of the decisions made.

There is an increasing need for tools and methodologies that can assess the financial impact of reuse in the preliminary stages while also considering the importance of preserving the historical and cultural integrity of the heritage. This delicate balance requires a continuous commitment to improving evaluation practices and promoting awareness of the importance of a responsible approach to cultural heritage.

4. Projects and Specific Actions for a "Circular" Urban–Rural Development

Recovery and Redevelopment of Historic Villages and Promotion of 'Rifugio Diffuso'

In line with recent research on the role of the AR and regeneration of cultural and landscape heritage in the transition towards a CE [14,17], the existence of integrated projects for the recovery and re-functionalization of historic centers can become a catalyst for private investments and contribute to the AR of resources that today represent a waste because they are unused.

In line with the principles of a circular perspective, the revitalization of historic centers in small municipalities aligns with a "systemic" and synergistic approach inherent to the CE. These centers are valuable economic, social, cultural, and environmental resources that can be leveraged, for instance, as hubs for new social entrepreneurship and as "Rifugio Diffuso" (RD) for promoting sustainable and slow-paced tourism. Embracing such initiatives is entirely consistent with circular development principles, as it emphasizes the utilization and regeneration of existing resources within a circular framework.

The RD is a model of innovative hospitality structure ('network') capable of generating cultural and economic wealth at the same time. As is known, it is a business for hospitality purposes located in the historic center of a single urban center that is made up of several properties close to each other and is able to provide hotel services.

The RD model aligns seamlessly with the principles of sustainable tourism by prioritizing the recovery, preservation, and promotion of an area's distinct traditions and peculiarities. It stands out by avoiding additional environmental impacts, as it revitalizes and repurposes existing historic buildings without requiring further land usage. Unlike traditional hotels, the RD model fosters a stronger sense of community and a deeper immersion of tourists in the local environment, enhancing the unique characteristics of the area. The RD model emphasizes the enrichment of the territory and the promotion of locally sourced products, making it a hallmark of sustainable tourism.

The promotion and enhancement of the short agri-food chain and of so-called "zero kilometer" products represent an effective "circular" territorial development strategy, especially if combined with forms of traditional multifunctional agriculture and "circular" agriculture [8–10]. Several recent studies have confirmed the data on Italy's attractiveness for food and wine resources. In addition to being the first country in Europe for the number of Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and GGS (Guaranteed Geographical Specialty) awards, "food and wine tourism, in 2017 counted 110 million presences in accommodation facilities (double compared to 2016), 43% of which due to Italian tourism (47 million visitors), while 57% to international tourism (63 million visitors)" [18]. It is therefore evident that the short supply chain can be identified as a strategic element for a "circular" territorial development, building both productive and tourist relations between the entire territory of the park and the surrounding historic centers and rural villages.

Considering the multifaceted value of cultural landscape assets and their potential integration into the local economic system, this contribution suggests a comprehensive multi-methodological framework. The framework aims to evaluate the technical, managerial, and economic–financial feasibility of integrated AR projects. Such projects have the capacity to attract private investments and stimulate local economic development by leveraging underutilized resources.

The proposed framework acknowledges the need to assess the viability of these projects from various angles, encompassing technical aspects, management strategies, and economic–financial considerations. By doing so, it provides a robust evaluation process that can effectively identify and capitalize on opportunities for AR. The ultimate goal is to incentivize the efficient utilization of resources that may not yet be adequately valued. By catalyzing private investments and promoting the integration of cultural landscape assets into the local economy, these projects can unlock their potential and contribute to sustainable and inclusive economic development.

Therefore, the aim of this pilot project is to foster the integration of the plurality of policies to respect and enhance the complex local reality and to seize the set of economic, social, and cultural opportunities that the dynamics of this context can trigger. This multi-methodological framework is discussed using a pilot project, represented by a project for the renovation and AR of a group of chalets inserted in the landscape context of Sila National Park (SNP) registered as the 10th Italian Biosphere reserve in the World Network of Sites of Excellence by UNESCO [7].

5. A Methodological Framework: Management and Economic–Financial Prefeasibility for the AR of Cultural Heritage

To effectively support decisions for the AR of cultural heritage, a methodological framework based on the integration of different methodologies has been set up (Figure 1). In particular, the development of a Financial Feasibility Plan (FFP) for verifying the economic convenience and financial sustainability of the RD will be described in a more analytical way, in line with the provisions of the EU guide for the 2014 cost–benefit analysis [52].

Phase 1. **Analysis of the Decisional Context**

- System Thinking Approach
- Istitutional Analysis
- SWOT Analysis

Phase 2. **Definition and study of intervention alternatives**

- Scenario Building

Phase 3. **Choice of the most favorable alternative**

- Multi-Criteria Analysis (MCA)

Phase 4. **Evaluation of the economic financial feasibility**

- Management model hypothesis
- Financial Feasibility Plan (FFP)
- Discount Cash Flows Analysis

Figure 1. Methodological framework.

As a pilot case, the village of Lorica (province of Cosenza) located in the Sila National Park (Italy) has been chosen because it offers a diverse territory, areas of high natural value, deep historical and cultural roots, and a strong tourist vocation compared to other provinces in Calabria. Hence, the choice of Lorica as a pilot case is particularly interesting for the initial application of more complex interventions, with high potential for the area, as they can attract a large number of hikers.

It is important to emphasize that the implementation of the methodology represents a real decision support system for more effective management of assets and the associated environmental and economic impacts, in favor of the local economy.

However, in the context of tourism development, the implementation of the proposed methodology is just the first step towards possible future applications. A future research objective is to build a comprehensive framework of the territory and classify the immense heritage of shelters in the park in a more detailed and transparent manner, making it easier for decision-makers to understand their strengths and weaknesses and decide how to orient management strategies at a central level for more balanced development.

The following subsections provide a brief description of the phases that constitute the proposed methodological framework.

5.1. Decision Context Analysis

Analyzing the decision-making context marks the initial stage of a methodological framework that assesses the managerial and economic financial prefeasibility of an RD project within the SNP. The process of recognizing cultural heritage values for the valorization of the AR project in the prefeasibility phase [13,24,26–28] is based on the integration of different cognitive approaches, including historical research, interviews with local experts in the field of conservation, and surveys on the field [17,21,24–28,34,35,42,45,46,50].

The evaluation process employs adaptive and synergistic approaches to assess the decision-making context. These approaches consider the unique characteristics of the study context, beginning with specific needs and examining potential conflicts. Rather than predetermined solutions, they emerge from the comparison of multiple interests, opportunities, and resources involved. By combining techniques like soft systems analysis and hard systems analysis [19], typical of systems thinking approaches [21], the evaluation unfolds as a learning process. It seeks to comprehend local specificities and the perspectives of various stakeholders [25,27,28], identified using the institutional analysis technique. This enables the identification of pertinent issues for decision-making. The development of intervention alternatives relies on informed knowledge, encompassing both expert and common knowledge. Moreover, it incorporates the “complex values” recognized and shared by the community. The methodological structure of the evaluation process is thus contextualized, integrating relevant methods and tools in a multi-methodological approach.

The results of the application of the system thinking approach were organized in a SWOT matrix (strengths, weaknesses, opportunities, and threats), thus providing a starting point for the design of context-aware AR strategies [6,25,27,47,51].

5.2. Definition and Study of Adaptive Reuse Alternatives

The alternative intervention scenarios [13,25] were developed using the scenario buildings technique [26], which systematizes the potential and development drivers of the park for sustainable tourism and the promotion of traditional culture [5,18,27,31,32]. These scenarios were built by integrating the heritage value system and local development trajectories, in line with the SWOT analysis and the knowledge of the complex values recognized and shared by the community.

5.3. Choose the Most Favorable Adaptive Reuse Alternative

The multidimensional nature of choosing the most favorable adaptive reuse alternative option requires the use of Multi-Criteria Analysis (MCA) as the best methodology to support the evaluation of alternative scenarios [16,26,47]. The robustness of the results from the MCA was tested through a sensitivity analysis, while the degree of consensus on the most favorable alternative was evaluated through the implementation of a social multi-criteria approach [28–30].

5.4. Evaluation of the Economic Financial Feasibility

The financial analysis was based on the setting up and development of an economic-financial model which makes it possible to correctly evaluate, based on the project data of the alternatives, the economic convenience and financial sustainability of a specific intervention for a private investor [53–55].

Economic convenience refers to the project's capacity to generate value and deliver a satisfactory return on the invested capital, meeting the expectations of private investors. Financial sustainability, on the other hand, pertains to the project's ability to generate cash flows that are adequate for repaying any loans obtained while also ensuring a suitable compensation for the private investors involved in the project's execution and management. On a methodological level, the process of setting up and elaborating the model developed according to the flow chart indicated in Figure 2, to which an iterative logic must be applied to take into account subsequent improvements and adjustments [53–55].

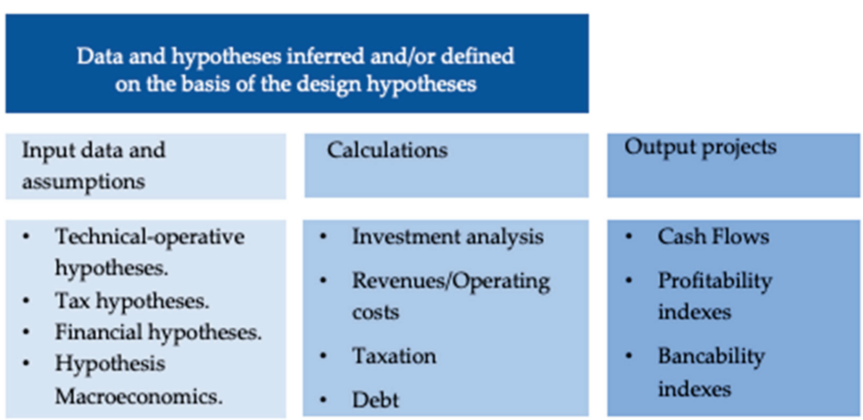

Figure 2. Financial Feasibility Plan (FFP) flow chart [56–58]. Source: data, evaluation, and estimates conducted by the authors up to 2023.

The objective was to develop, through the identification of the main economic and financial parameters typical of the investment project under consideration, an estimation for 2023 (revenue system, investments, management costs, etc.). The definition of revenue was based on a market analysis of similar activities in the national and local context and on real estate prices from the Osservatorio del Mercato Immobiliare (OMI) [56]. The assessment of investment costs [57] was based on the price lists for the public and private works currently used in the Calabria region as well as data provided in the DEI—Prezzi Tipologie Edilizie [58]. These costs were also validated by consulting local operators and construction companies. The management costs were determined by considering the costs typically incurred by operators in the local market.

The Financial Feasibility Plan (FFP) aim to preliminarily identify the following:

- The income capacity of the activities to be managed with the implementation of the project (provision of services or production of goods).
- The financial requirements related to the execution of the works and the investment.
- The economic–financial sustainability was identified by comparing the level of profitability of the project with the average deemed acceptable by private investors and financial institutions, with reference to similar initiatives carried out in the same sector to which the project belonged. In relation to this comparison, with the aim of bringing the profitability of the project closer to that expected and/or required by private investors, the assumptions for structuring the revenue were subsequently modified.

5.4.1. Preparation of the Financial Feasibility Plan

The Financial Feasibility Plan (FFP) represents the moment of systematization of all the data and hypotheses concerning the reality examined (investment project). Its development through a system of interdependent accounts makes it possible to determine the economic feasibility of the initiative and the project's ability to repay the debt and remunerate the risk capital [53–55].

Based on the data collected and the results of the analyses conducted, the first part of this work was developed, which was connected to the operational management of the project based on the cash flow analysis [53]. In this first phase, the construction of the FFP made it possible to identify some items of particular importance for carrying out the subsequent assessments concerning the economic convenience of the project, including:

- The Gross Operating Surplus (GOS), given by the difference between the revenue and operating cost, and the operating income, which includes the sum of depreciation realized during the year deducted from the GOS.
- To calculate the cash flow, the amount corresponding to the cash flow generated by management, the Free Cash Flow from Operations (FCFO) for each period is equal to the operating result attributable to the initiative itself and net taxes, plus depreciation and minus the positive change in trade capital attributable to the project.

The analysis of the economic convenience linked to an investment can be set up by referring to different valuation methodologies. Among these, the most commonly used are those based on the calculation of specific indicators suitable for providing a summary judgment on the investment's ability to create value and generate adequate profitability. In this regard, it intends to refer to the criteria of the IRR (Internal Rate of Return) and the NPV (Net Present Value).

Evaluation Criterion Based on the NPV

The evaluation criterion based on the NPV represents the incremental wealth generated by the investment, expressed as if it were immediately available at the instant in which the evaluation is made. Analytically, it is determined as the algebraic sum of the operating cash flows expected from the implementation of the intervention, discounted at the rate corresponding to the estimated cost of invested capital.

A positive NPV essentially testifies to the project's ability to free up sufficient monetary flows to repay the initial costs, remunerate the capital employed in the operation, and possibly leave resources available for further destinations.

The general formula for calculating the NPV [53] can be expressed by Equation (1):

$$NVP = \sum\nolimits_{t=1}^{n} \frac{F_t}{(1+i)^t} = \sum\nolimits_{t=1}^{n} \frac{(R-C)}{(1+i)^t} \quad (1)$$

where:

F_t = Cash flows at time t (with t varying from 1 to n)
R = Revenues (rentals or sales)
C = investment and management costs
i = interest rate or discount rate, equivalent to the opportunity cost of capital
n = duration of the investment

The NPV criterion is an evaluation method that fully considers the three factors based on a correct judgment of economic convenience, including the integral series of expected differential cash flows, their temporal distribution, and the financial value of time.

In the specific case in the equation of the NPV, the cost of the invested capital "i" is calculated as the weighted average of the cost of its own capital and the cost of the debt capital (WACC—Weighted Average Cost of Capital) [53]. Therefore, Equation (1) can be written in the following form shown in Equation (2):

$$NVP = \sum\nolimits_{t=1}^{n} \frac{F_t}{(1+WACC)^t} \quad (2)$$

Evaluation Criterion Based on the IRR

The evaluation criterion based on the Internal Rate of Return (IRR) is defined as the discount rate for which an investment has an NPV equal to zero [53] at which the economic result of an operation is zero, as shown in Equation (3).

$$IRR = i \quad where: \; NVP = 0 \quad (3)$$

The evaluation criterion in question provides for the comparison between the IRR calculated for the project and a threshold rate which, consistent with what was declared in relation to the NPV, will correspond to the estimated cost of the invested capital. Therefore, when an investment has an IRR return greater than the opportunity cost of capital, the project is economically sustainable [53–55].

Not all economically viable investments are financially feasible. The expression "financial sustainability" refers to the project's ability to generate a cash flow that is sufficient to guarantee the repayment of loans and adequate profitability for shareholders. This can be represented by the simple condition according to which the cumulative net cash flow, determined as the sum of the annual net cash flows, always assumes a positive value at a limit equal to zero for each period of analysis considered.

The financial sustainability of a project can also be expressed in terms of bankability, with reference to particular indicators capable of assessing the margin of safety with which the lenders can be guaranteed timely payment of the debt service.

There are two main coverage ratios considered:

- Debt Service Cover Ratio (DSCR)
- Loan Life Cover Ratio (LLCR)

Evaluation Criterion Based on the Debt Service Cover Ratio

The Debt Service Cover Ratio (DSCR) is a valuation criterion that compares the operating cash flow, including both the repayment of the principal amount and the interest. This ratio is calculated for each period within the envisioned time horizon of the loans. The

DSCR serves as a measure of the project's ability to generate sufficient cash flow to cover its debt obligations, considering both the capital share and the interest share.

The Debt Service Cover Ratio (DSCR) has a straightforward interpretation: a value equal to or exceeding one signifies that the investment generates ample resources to meet the debt repayments owed to the lenders. However, for the ratio to be considered acceptable, the minimum value should not be precisely equal to one. This is because the ability to distribute dividends to shareholders would be jeopardized until the entire debt is repaid. Furthermore, when calculating the DSCR in a forward-facing manner, it is reasonable to assume that lenders would require an appropriate margin of security.

However, there is no universal benchmark for debt coverage ratios. The acceptable limit is subject to negotiation and depends on factors such as the project risk, provided guarantees, and contractual strength. The specific level will vary based on the unique circumstances of each project and the parties involved in the agreement.

Evaluation Criterion Based on the Loan Life Cover Ratio

The Loan Life Cover Ratio (LLCR) is defined as the ratio between the discounted sum of cash flows available for Debt Service, which are between the valuation instant and the last projected year for loan repayment, and the residual debt considered at the same instant of valuation. The numerator of the ratio represents the present value of project-generated cash flows on which the financiers can rely for future repayment of the amounts still owed (expressed in the denominator). Based on the above, it is evident that the higher the considered coverage index assumes values above unity (equilibrium point), the greater the financial soundness of the investment and the repayment guarantee obtained from financiers.

6. Application to the Case Study

6.1. An Adaptive Reuse Project of "Rifugio Diffuso" in Sila National Park

The illustrated methodological framework was applied to a case study relating to a "Rifugio Diffuso" project in Sila National Park (Italy) (Figure 3). The SNP, a national park in Calabria, Italy, was founded in 1997, spanning approximately 74,000 hectares. It safeguards a remarkable biodiverse landscape and scenic beauty, earning recognition as the 10th Italian biosphere reserve in UNESCO's prestigious network of outstanding sites in 2014 [7].

Figure 3. The study area. Source: elaboration by the author.

Despite the centuries-old interactions between men and nature, the landscape has maintained a harmonious relationship between human activities, the natural environment, and urban settlements. Approximately 386,000 inhabitants live in the territory of the reserve, mainly dedicated to agriculture, forestry, and breeding (transhumance of livestock is still practiced, from the mountains to the coastal plains in winter and vice versa). Calabria is the fourth Italian region in terms of the number of protected products, with 36 denominations, especially in the wine and cured meats sectors [7].

The settlement system is structured on the network of historic centers, inserted in the landscape and often well preserved. In addition to the system of historic centers, the numerous small rural villages have landscape value, functional to the maintenance of rural activities and secular rites and traditions and functional to the pursuit of enhancement strategies centered on visitors.

In the context of the study, the distribution of the population was influenced over time by both natural and historical factors. The population that currently lives in the park's territories is rather scarce. The most densely populated areas were found at the confluence of the valleys, while the towns/hamlets that, due to their position, had difficulty accessing them, have undergone a progressive depopulation in the last sixty years. To preserve the local cultural identity and stop this phenomenon, numerous regional and community projects have been launched in recent years, bearing witness to the importance of safeguarding and enhancing this common heritage through the promotion of sustainable and integrated intervention policies with respect to different cultural, historical, social, and economic contexts. To date, the territory of the park is undergoing a demographic collapse that began in the last century. The causes of depopulation can be identified in changes in the standard of living, as well as in the increasingly limited availability of primary services. In fact, it is no longer possible to lead a life in the mountains except for short holiday periods.

If the infrastructural network is lacking from a purely functional point of view, it should be pointed out that the presence of a secondary road network, which often offers extraordinary perspective opportunities, would deserve a detailed analysis aimed at identifying the most panoramic stretches for designing viewpoints and explanatory signs of the observable landscape peculiarities.

The historic–cultural system is made up of sets of punctual assets within four main categories: industrial archeology (spinning mills, kilns, production plants); historical and cultural assets (archaeological areas, castles, fortified settlements, museums, necropolises); religious properties (abbeys, chapels, churches, convents, monasteries, sanctuaries); and rural assets (farms, mills).

6.2. Decision Context Analysis

The initial phase of the methodological path explores the decision-making context of the study for the project of 'Rifugio Diffuso' in the SNP. All relevant information on the project area, collected through the integration of Hard System Analysis, Soft System Analysis, and Institutional Analysis, was structured in a SWOT matrix (Strengths, Weaknesses, Opportunities, and Threats): a valid reference for planning adaptive reuse strategies [59]. The Hard System Analysis enabled the development of a comprehensive cognitive framework encompassing the physical, morphological, social, and economic aspects of the study area. This framework served as a valuable reference for constructing the SWOT matrix. Additionally, the Institutional Analysis technique [19] was employed to identify and map the relevant stakeholders in the local community. Their interests were explored through online questionnaires and interviews with key individuals. The outcome was a place-specific SWOT matrix that incorporated both expert perspectives and insights from the local communities. This matrix effectively captured the factors that were best-recognized by those who resided in the area.

Strengths and Weaknesses of the Socio–Economic Context

The current state of affairs was analyzed and the intervention needs were identified for the purpose of reaching the definition of the strong points of the territory and its criticalities, dynamics and evolutionary prospects, and threats to which it is subjected. According to the criteria of the SWOT analysis, the following points were identified:

- The Strengths were represented by the resources that were present and usable and by the ability of local actors to self-organize and cooperate.

- The Weaknesses were represented by the elements to be removed, such as the irrational exploitation of the soil, the difficulties in maintaining the landscape, the cultural and infrastructural heritage, and the fragility of the social and economic system.
- The Opportunities that emerged were for the recovery and mending of areas of naturalistic interest and the historical–cultural heritage, for the sustainable development and consolidation of activities (such as tourism), and for the development of the local economic and social fabric;
- The Threats of concern were the economic, social, and cultural processes on which development prospects were based, considering both internal and exogenous dynamics.

On the one hand, the comparative analysis of the Strengths and Weaknesses of the territory made it possible to identify the areas, objectives, and actions on which to "leverage" to promote the triggering of sustainable development models and remove/mitigate the processes/elements of degradation. On the other hand, the examination of the Opportunities and Threats made it possible to define strategic hypotheses with which to orient the objectives, axes, and actions. In general, from a demographic point of view, the park presented an overall situation characterized by a significant decline in the resident population, as well as an evident aging trend. This was accompanied by a low level of per capita income, below the national average, and poor endowments of social structures. This socio–demographic situation was accompanied by an economic and entrepreneurial context that was not oriented towards the agricultural sector, which represents a vital sector for the protection and control of the territory. In particular, the problems and criticalities within the socio–economic context of the park could be traced back to the following factors: depopulation in the municipalities, population aging, fragility of the social and economic context, low endowment of structures and infrastructures serving the production system, high fragmentation of supply and production, difficulties related to logistics and freight transport, poor training of economic operators, low propensity of economic operators to associate and collaborate, and little consideration of the park authority as an interlocutor, both at an institutional level and as private operators. Alongside the weaknesses, the following strengths were highlighted: good institutional organization of the park authority, a variety of typical products and a good quality of most of the dairy and agricultural products, and the availability of cultural resources and "ancient trades" linked to ancient production techniques. Table 1 schematically outlines the results of the SWOT analysis.

Table 1. SWOT analysis of the socio–economic context.

Strengths	Weaknesses
• Good availability of second homes to be used as accommodations. • Presence of significant cultural typicalities. • Diversification of sports activities. • High naturalistic value. • Presence of historical and religious values to be valorized. • Presence of chalet and villages to be restructured and dedicated to hospitality and services for tourism. • Presence of mountain pastures and structures to be consolidated and valorized. • Presence of demonstrations and events linked to local tradition and culture, rooted in history and identity. • Presence of events of regional and national appeal in neighboring territories • Presence of a varied and deep-rooted heritage of ancient crafts. • Strong local identity. • Rooting of the artisan tradition in the collective imagination.	• Poor recognition of local products to be used for tourist consumption. • Poor associative capacity of tourism operators. • Presence of second-home tourism that does not generate related activities. • Poor basic services (bank, transport, health facilities, youth meeting places, etc.). • Absence of an organization and overall coordination of an offer that is highly competitive and recognizable. • Aging of the repositories of ancient wisdom. • Dispersion of agricultural production and reduced farm size. • Scarce diversification of the present productions. • Poor diversification of agricultural production. • High average age of farmers.

Table 1. *Cont.*

Opportunities	Threats
• Increased demand for high-quality nature tourism, especially from abroad. • Existence of projects for the development and promotion of alternative and sustainable accommodation at national and international level. • Enhancement of typical products also through certification. • Connection of the park with national and international circuits or events. • Protection and enhancement of traditions and local identity as an element of attractiveness and competitiveness for the area. • Integration and coordination between the offer of events and exhibitions and the accommodation offer (winter and summer sports, nature tourism, etc.). • Creation of a collective brand for all the Park's products. • Driving force for the creation of an endogenous and integrated rural development model based on the enhancement of the agriculture-environment–territory relationship. • Community and regional programming for the territory development.	• Competition from tourist offers from nearby natural areas and from those better equipped for winter and summer sports and those equipped with basic services. • Persistent under-utilization of accommodation capacities resulting in a low employment capacity. • Social fabric not inclined to entrepreneurial activities. • Lack of connection between existing initiatives. • Absence of a recognizable and competitive image of the cultural identity of the territory. • Failure to use modern production techniques. • Scarce use of regional incentives. • Exodus of the workforce from agriculture with the consequent abandonment of the territory and impoverishment of the economic–social fabric. • Abandonment of traditional techniques of cultivation and land management, with consequent problems related to land and landscape maintenance.

Based on the analyses carried out, three fundamental strategic axes emerged to pursue the conservation, enhancement, and promotion of the SNP territory:

- Conservation of natural resources: (i) fauna, flora, forest heritage, and water resources; (ii) integrated organization of the social use of the park and promotion of its image at an international level.
- Sustainable development of local populations: (i) improvement in accessibility to services; (ii) strengthening of the endogenous factors of development, in particular human capital, through training and support activities.
- Sustainable development of tourism and the territory: (i) enhancement of the historical, cultural, and landscape heritage; (ii) enhancement of agro–pastoral activities and crafts; (iii) qualification and enhancement of accommodation facilities.

6.3. Definition and Study of Adaptive Reuse Hypotheses

The results of the analysis of the decision-making context systematized in the SWOT matrix (Table 1), together with the process of recognizing cultural heritage values, allowed the project to become compatible with the value system of the project area and to design development and alternative reuse development. In more detail, as mentioned above, the SWOT analysis highlighted three fundamental strategic axes, which were useful references for developing a project aimed at seeking the conservation, enhancement, and promotion of the park territory, leveraging local potential and addressing existing critical issues.

The SNP falls within a rather complex socio–cultural system. In fact, it includes areas in which opposite and contradictory characters coexist: an endowment of environmental, natural, anthropic, and historical resources that is underexploited in the sense of valorization and overexploited with respect to its carrying capacity.

A fundamental role of the pilot project was to favor the integration of the plurality of policies, to respect and enhance the complex local reality, and seize the set of economic, social, and cultural opportunities that the dynamics of the context can trigger. For this reason, the method of "concerted programming" assumed particular importance, which was launched with the subjects involved: the local administration, park authority, state forestry corps, and private owners.

The bottom-up logic requires consensus and sharing within the limits and in compliance with current legislation, seeking the support of the institutional subjects and local actors involved to enhance the synergies between the various interest groups (stakeholders) and the complementation of skills, reducing the reasons for conflict. The moments of dialogue put in place by the research group ensured an effective comparison based on the explicit evaluation of the expected results and the risks of the design hypotheses.

Engaging the local community through questionnaires and interviews helped in identifying sustainable adaptive reuse strategies aligned with their expectations. It also revealed the community's social perception of cultural values, highlighting key elements for preserving and enhancing a collectively supported adaptive reuse project. The alternative scenarios of the adaptive reuse project are defined by applying the scenario building methodology [26], exploiting the potential and development drivers of the areas through sustainable tourism and the promotion of traditional cultures [5,25,31].

Through an in-depth analysis with the stakeholders allowed us to analyze and verify a series of aspects necessary to move from the generic identification of possible lines of development to the definition of the local development plan. The details of the path subsequently followed in the context of the analysis phase are described below:

- Analysis of the hypotheses of intervention that emerged following the initial reading of the scenario data.
- Degree of sharing at the local level of the intervention hypotheses that have emerged and their consequent refinement.
- Analysis of similar experiences already in place and the reasons for their functioning (good or bad) and their capacity to respond to local needs.
- Shared description of the supply and demand of the good or service intended to be developed and analysis of market functioning.
- Identification of the actors (both public and private) to involve for the project to work.
- Analysis of the resistances to overcome.
- Identification of the strengths and weaknesses of the project.
- Construction of the local plan: definition of operational steps, specification of development guidelines, possible review of data or acquisition of new data, gathering additional approvals, and drafting and sharing of the feasibility study.

As mentioned, once the project guidelines were defined, they were shared with the local partners to define the actions to be undertaken in a participatory manner and clarify the methods and actors for implementation (Table 2). An important moment in defining the preferred intervention alternative was represented by the continuous exchanges with the local actors who actively participated in the planning of the idea. In fact, after the analyses conducted on the existing structure, their participation in all the verification phases contained in the prefeasibility study was considered essential for sharing the analyses and intervention hypotheses. Thus, one of the development possibilities was clarified, which was identified in the connection between the tourist and agricultural sectors; more precisely in the creation of activities aimed at linking tourism with the agro–forestry–pastoral and artisanal activities connected with or attributable to it.

Table 2. Analysis of intervention and adaptive reuse alternatives.

Alternatives		Strengths	Weaknesses
A1	Building recovery of properties with residential use ("second home") in accordance with current legislation	• Ease of the transformation process	• Disparity of the intervention • Absence of an impact on the socio–economic context
A2	Refurbishment of buildings with a new accommodation destination and sale of products from the milk supply chain	• Sustainable destination • Enhancement of local traditions • Driving force for local development	• High fractionation of ownership • Complexity of management of the transformation process

A fundamental prerequisite for implementing the hypothesized actions, in line with the analyses carried out, is the involvement of all local actors (public and private). The advanced hypotheses were then shared with the local actors through the scenario building technique [26]: a technique developed by the U.E. for involvement in a perspective of governance and democratic deliberative participation [21,24,26–28]. The participants were calle upon to engage in structured discussions to reach a consensus on the path forward, including planning and defining the tasks and actions to be undertaken.

The scenario building, in addition to providing the basis for consensus on the actions to be undertaken (and on the methods for implementing them), should lead to the definition of the premises for the establishment of a collaboration network, which will subsequently have to be institutionalized and publicly supported. The development of new type of offer, accommodation or otherwise, is a problem that concerns private entrepreneurs, the local socio-economic conditions, and the understanding and collaboration of tourist entrepreneurs with local public administrators. By planning resources and interventions together, the public and private actors will be able to move towards an advanced tourism which has the fundamental and innovative objective of providing the means and equipment, in harmony with the development of local peculiarities. It is evident that it is not enough to prepare "positive" interventions top-down. The objective must be pursued in a participatory process which, by identifying specific organizational references, is able to combine the equipment, services, and methods of use with real needs so that they can be managed over time using valid methods and criteria.

Table 2 summarizes the two operational development alternatives that emerged from the re-elaboration of the analyses conducted and from the comparison with local actors.

6.4. Choosing the Most Favorable Adaptive Reuse Alternative

The development of the adaptive reuse project, coherent with the local development trajectories of the SNP and its high cultural value, requires a careful evaluation of the alternatives to identify the favorable one. The evaluation is based on a Multi-Criteria Analysis (MCA) using the Electre method [47,60]. Consistent with the chosen methodology, the two alternatives were evaluated in terms of performance according to a series of defined criteria and a weighting system linked to the strategic objectives of the adaptive reuse project. Based on the application of the Electre method, the alternative A2, the redevelopment of the buildings with a new accommodation destination and sale of products from the milk supply chain was the most favorable adaptive reuse alternative for the implementation of the project for the adaptive reuse.

Given the decision's complexity and uncertainty [61], a sensitivity analysis was conducted. To assess the result's robustness [62], the 'Monte Carlo' method was employed, involving varying input values used in the analysis. This approach helps gauge the impact of different scenarios on the outcome [63].

Having verified the solidity of the final result, an Equity analysis was applied using the NAIDE method [64], in which the possible conflicts between the different groups of stakeholders involved in the evaluation were analyzed, and the level of consensus on the two alternatives was defined [65].

The implementation of the equity analysis revealed that alternative A2 demonstrated the highest level of alliance between the different stakeholders, wheras alternative A1 was less convincing and weaker in terms of socio–economic development of the PNS, enhancement of mountain pastures, and promotion of local development. In particular, regarding the accommodation destination, it became evident that alternative A2. it more conducive to "sustainable tourism" in harmony with the natural context of the village and park, as it preserves the overall vision of the PNS. Therefore, alternative A2 is confirmed as the most favorable option for the adaptive reuse project to be implemented and evaluated, also in terms of economic sustainability.

6.5. Feasibility Checks for the Adaptive Reuse Project

Once the preliminary fact-finding analyses were carried out and the most favorable alternative was identified, the technical and economic financial feasibility of the project was verified. Initially, some preliminary indications were provided based on the technical feasibility and the pre-project checks, both for the recovery of the chalets (identified as a start-up nucleus) and for the farmhouses in the mountain pastures.

6.5.1. Technical Feasibility

The Recovery of Chalets: Critical Ideas for the Transformation

With regard to the transformation of the chalets, in full compliance with the regulations envisaged for the work to be carried out in park areas, the re-functionalization of the chalets would have to maintain the characteristics of the local architecture and the use of typical local materials, providing for a recovery based on traditional techniques so as not to impact the surrounding environment. Particular attention will be paid to the external arrangement of the areas and specifically to the restoration and new construction of the paths inside the village, as well as to the arrangement of the access mule tracks. As far as energy saving is concerned, all necessary measures must be taken to content consumption, also using new technologies and systems to control heat loss. The project could include the use of renewable energy sources. The social value of the intervention is linked, in addition to the global recovery action of the nucleus with conservative criteria, to the fact that the sale of the real estate units is not envisaged, but rather a unitary management that maintains the original character of the village. As mentioned, one of the recovered chalets (or part of it) could host a point of sale of typical products, and the remaining part of the start-up nucleus would be destined to accommodate premises for widespread hospitality and a refreshment point for the non-exclusive use of the users of the structure.

Recovery of the Pastures

As far as the recovery of the mountain pastures is concerned, the difficulties usually concerned the adaptations to health regulations (in particular with regard to the potability of water) and inconveniences due to isolation. While respecting the fundamental rules of hygiene, the local architecture and the choice of construction materials must be safeguarded as far as possible in the cheese-making premises already existing in the mountain pastures. To this end, the minimum structural and hygienic requirements for the cheese-making rooms in the mountain pastures were provided.

6.5.2. Economic Financial Feasibility of the 'Rifugio Diffuso'

Once the technical feasibility had been explored, it was essential to verify the economic financial feasibility. First of all, it is necessary to examine in detail the functions of the intervention, investigate the potential and residual housing demand, and define the input data of the financial plan of the accommodation facility.

Potential Demand and the Existing Accommodation Offer

The tourist flows of the SNP show that over the last decade, there has been an increase of approximately 9.6% [66,67], mainly recorded in the post-pandemic period. This value was mainly determined by Italian tourists (+104.8%), who had shown a growing interest and appreciation for the Sila area. Foreign tourists also arrived in greater numbers than in the past and tended to stay longer. On the other hand, Italian tourists reduced the duration of their vacation, in line with the behavior observed at the national level. The average length of stay of tourists inside the Park was 4.79 days [66]. In terms of usage patterns, it emerged that the green holiday was mainly chosen by couples (44.4%), families with children (20.9%), and single individuals (13.5%).

The accommodation system of the area was characterized by a general lack of structures and beds and by an uneven distribution throughout the territory. Approximately 30% of the structures present in the entire area consisted of shelters and bivouacs, which accommodated to the needs of a specific segment of tourists who enjoy trekking to reach areas only avaliable by foot. In most cases, they do not lend themselves to satisfying a potential "light and widespread tourism" capable of causing positive economic effects directly on the local tourism system. The accommodation offer was predominantly made up of medium, small-sized, and medium-category hotels. The higher standard hotels are concentrated in Lorica, while there was no consolidated offer of non-hotel structures such as farmhouses, B&Bs, guest houses, and holiday homes. It is a tourist offer still linked to traditional models and poorly integrated with the valorization of the territory's own resources.

Currently, the park is characterized by short-break users, who stay for a short time, usually on weekends, in the months of July and August. It is a heterogeneous type of tourism, whose consumers are mainly families. Tourism in the area is oriented towards nature, is respectful of the environment and local communities, and expresses diversified benefits (relaxation, sporting activities, socio–cultural entertainment), lending itself well to the environmental context of the park, which is characterized not only by significant naturalistic elements but also various folkloric curiosities.

Dimensional Hypothesis of the Start-Up Nucleus

A start-up nucleus of RD was identified in the village of Lorica. This nucleus consists of five units: those marked with numbers from 1 to 4 will be located the 40 rooms, and the common services will be located in block 5 (Figure 4). The covered area is approximately 500 sqm.

Figure 4. The nucleus of start-ups of the "Rifugio Diffuso". (Google Earth Lorica: 39°15′01.26″ N 16°30′42.59″ E). Source: elaboration by the author. Legend: Rooms blocks 1, 2, 3, 4; Common services block 5.

Total Investment Cost

The recovery of the chalets, in compliance with the specific regulations envisaged in park areas and with the typical characteristics of traditional mountain architecture, involves a parametric cost of 1500 euros/sqm. The start-up nucleus of the widespread shelter, consisting of 500 square meters, will therefore cost approximately 750,000.00 euros. The total amount envisaged for the recovery of the widespread refuge chalets and for the arrangement of the access roads to the village, as per the technical–economic framework, pursuant to national legislation, developed based on the project hypotheses put forward, was 1,149,608.00 euros (Appendix A). Among the sums available to the contracting station were the total cost of the purchase of the barracks by the administration (start-up group), equal to 40,000.00 euros. This cost was derived from a synthetic estimate and elaborated based on direct surveys of local real estate operators: 500 sqm × 80.00 euros/sqm = 40,000.00 euros. It should be noted that this total cost does not include the costs for the purchase of furnishings and equipment for the rooms, the common areas, and the bar/restaurant area of the widespread refuge, which was assumed to be borne by the manager of the accommodation business.

Management Model Hypothesis

Based on the comparative information of best practices, two main types of management can be hypothesized:

- Direct management of the municipal administration.
- Management entrusted to third parties (private, service cooperative, social cooperative, etc.).

Table 3 displays the advantages and disadvantages of the two hypothesized solutions.

Table 3. Advantages and disadvantages of the management hypotheses.

Direct Management	Management Entrusted to Third Parties
Advantages	**Disadvantages**
• Possible saving of resources in finding the manager within the administration. • Possible triggering of economies of scale in the integrated management of other existing public accommodation facilities. • Creation of employment opportunities • Presence of personnel suitable for carrying out the activity • Greater motivation to develop and grow the business	• Excessive workload for the administrative structure. • Difficulty in finding the available resources. • Less propensity to organize events and launch activities for the accommodation facility. • 'Enterprise risk' in management imbalance.

The primary objective of the municipal administration is the return in terms of positive effects and benefits that the initiative can trigger on the territory. Among these benefits, the first is the increase in tourist attractiveness of the municipality of the township, which is reflected in many facets:

- improvement in employment and the local economy
- diversification and cultural growth of the territory
- containment of labor emigration factors

Based on these assumptions and the result of the comparison between the management alternatives, it was considered more advantageous to entrust the management to third parties in order not to further burden the administration with an onerous task that can be carried out with greater ability by entrepreneurs in the receptive field [24,25,27,30]. In fact, direct management by the administration is almost always an inadvisable path, as the public body may experience difficulty in internally obtaining the resources and professionalism necessary for the promotion and development of side-initiatives to its core business.

Finally, the possible future synergy of the structure with other functions aimed at the development and enhancement of local and tourist attractions should be highlighted, such as the promotion and resale of products from the milk supply chain and the organization of guided visits to the mountain pastures.

Finally, the possible future synergy of the structure with other functions aimed at the development and enhancement of local and tourist attractions, such as the promotion and resale of products from the milk supply chain and the organization of guided visits to the mountain pastures should be highlighted.

Below are the main possible stages of implementation of the intervention:

The Municipal Administration:

1. Purchase cabins from private owners
2. Renovate buildings
3. Recover the existing internal road system

4. Entrust the management of the RD to private individuals
5. Receive rent from the private manager

The Financial Feasibility Plan of the Accommodation Facility—Input Data

The hypotheses formulated for the preparation of the Financial Feasibility Plan (FFP) of the RD, based on the functions that could be established (10 rooms for a total of 40 beds; common areas; bar/restaurant), concern the duration of the lease, initial investment, financial structure of the investment, amortization of the initial investment, management costs, ordinary maintenance costs, rental fee, income from room occupation, and bar/restaurant service, as indicated below:

- The duration of the 20-year lease.
- An initial investment cost, which includes the amount necessary to purchase the furnishings and equipment of the rooms, the common areas, and the bar and restaurant (Table 4).
- For the financial structure of the investment, it has been estimated that the most suitable mix of financial resources to finance the investment is made up of 30% risk capital (financing supported by the manager) and 70% debt capital (financing supported by taking out a mortgage with a credit institution). The loan term was assumed to be 10 years.
- The amortization of the total initial investment was spread over 20 years, with an annual rate of 5%, equal to 3000.00 euros. Furthermore, a further investment was assumed in the 11th year for the partial replacement of the furnishings (equal to 30% of the initial investment, i.e., 18,000.00 euros), the depreciation of which, distributed over 10 years starting from the 11th, provides for an annual rate of 10% and equal to €1800.00.

Table 4. Investment costs for management.

Furnishings	U.M.	Unit Amount Euros	Total Amount Euros
Quadruple rooms	n. 10	4000.00	40,000.00
Common areas, Bar, Restaurant, etc.	lum sum	20,000.00	20,000.00
Total investment			60,000.00

The framework of overall management costs, calculated based on a period of activity of the established functions equal to six months/year (150 days), includes:

- The costs of operating personnel (two managers and one resource); in this way, it is foreseen that the structure can remain open for 16 h a day (from 7.00 to 23.00).
- Promotion and advertising expenses: these activities must be traced back to a general strategy, which will concern the communication of the new accommodation facility.
- Expenses relating to utilities: electricity supply, water supply, and heating (estimates relating to consumption must be considered approximate and based on the data available in the design hypotheses, referring to the total area of the chalets equal to 550 sqm). In particular, the electricity requirement was assumed to be a cost of 5.00 euro/sqm, equal to €2500.00/year; for heating 6.00 euros/sqm, equal to €3000.00/year; and for the water supply of 1.30 euro/sqm, equal to €650.00/year.
- Regarding expenses for various materials (supply of sheets, blankets, soaps, etc., as well as the pantry of bars and restaurants), the cost was estimated equal to approximately 20% of the revenue, according to the occupancy percentage of the rooms for the year).
- The amount relating to maintenance costs was estimated to be 0.20% of the investment costs (750,000.00 euros, excluding furnishings): 1500.00 euros per year for the first five

years. From the 6th to the 10th year, the rate was set at 0.40% (3000.00 euro/year) and from the 11th to the 20th year at 0.60% (4500.00 euro/year).

- Regarding the rental fee, in drafting the FFP, it was assumed that the manager would start paying the rent from the fifth year. The amount of the annual rent was estimated to be 9000.00 euros based on the following assumptions:
    - initial investment = 750,000.00 euros
    - economic duration of the asset = 80 years
    - initial investment depreciation charge = 9375.00 euros/year
    - rounding down the initial investment depreciation charge = 9000.00 euros/year.
    - The revenue analysis evaluated, based on a hypothesis of user flows, all the possible revenue sources in relation to the different types of profit that the overall range of services produces (Table 5). These types consist of:
        - Sale of beds in quadruple rooms (school groups, young people, etc.).
        - Sale of double/triple/quadruple rooms for families.
        - Drinks in the bar/restaurant area (breakfasts, lunches, and dinners) ordered by the users of the shelter.
        - Drinks in the bar/restaurant area ordered by passing users.

Table 5. Revenue from occupation of the rooms and bar/restaurant service.

Typology	n. Nights—Rooms/Year	Rate Euros	Annual Revenues Euros	Occupation 1st Year %	Occupation 2st Anno %	Occupation 3st Anno %	Occupation 4st Anno %
Quadruple rooms school groups (€12.50/child)	150	50.00	7500.00	100	100	100	100
Double rooms	450	40.00	18,000.00	50	55	60	65
Triple rooms	450	50.00	22,500.00	50	55	60	65
Quadruple rooms	450	60.00	27,500.00	50	55	60	65

Based on the hypothesis of opening the accommodation business for 150 days/year, a percentage of occupancy of the beds/rooms increasing from the first to the fourth year was very prudently evaluated, keeping the user tariff unchanged (including VAT, without considering the changes relating to the adjustment due to the ISTAT index of consumer prices on an annual basis for families of workers and employees) (Table 5).

As mentioned in the previous sections, the potential offer of the planned structure was equal to 1500 rooms/year (i.e., 40 beds $\times$ 150 days/year = 6000 room nights/year).

Considering that there are an average of 3000 school children on trips to the SNP per year and assuming that 20% could use the new accommodation facility, the occupation of the refuge by this specific user demographic represents 10% of the offer potential: 20% of 3000 children/year = 600 children/year = 150 rooms/year occupied by school groups (rooms with 4 beds each). This hypothesis remains unchanged for all the years of management, representing 100% of the occupancy of the rooms for school groups.

With regard to the residual supply of rooms per year, it was estimated that it could satisfy the demand represented by families. In particular, it was prudently assumed that the remaining 1350 rooms/year could be occupied by two, three, or four people, up to a maximum of 65%.

Therefore, the occupation of the structure varied from a minimum of 55% in the first year of management to a maximum of 68.50% from the fourth to the twentieth year.

With regard to the bar/restaurant service, it was assumed that:

- 90% of guests would consume breakfast in the structure, for an average cost of 2.00 euros each.

- 50% of guests would eat a full meal (lunch or dinner) for an average cost of 12.00 euros each.
- 50% of guests would spend an average of 5.00 euros each at the bar (sandwiches, drinks, etc.).

An 'independent' attendance at the bar/restaurant equal to 400 passing users was also evaluated, which was represented by a percentage of 50% of potential consumers, for a cost of 3.00 euros each, guaranteeing a total annual income of 6000.00 euros.

It should be noted that the total number of transit users was estimated based on data relating to the presence of tourists (school groups and excursionists) in the SNP and its surroundings.

- The direct taxes considered were IRPEG, with an annual rate of 32% and IRAP, with an annual rate of 4.25%

Development of the Financial Feasibility Plan

Appendix B shows the development of the FFP based on the user flow hypotheses and possible revenues in relation to the different types of profit that the overall offer of services produces.

It should be noted that a WACC of 8.98% was used to discount the cash flows, obtained with the following equation [53,54]:

$$\mathrm{WACC} = \mathrm{K_E}\,\frac{E}{D+E} + K_{\mathrm{D}}\,\frac{D}{D+E}(1-t) \tag{4}$$

where:

E = equity capital

D = debt

K_E = rate of return on equity capital

K_D = rate of return on debt

t = tax rate used to calculate the tax benefit resulting from the deductibility, for direct taxes purposes, of financial charges (so-called tax shield)

7. Discussion of the Results

This paper presents the development of a technical and economic–financial prefeasibility study related to a project aimed at reusing underutilized cultural assets for "Rifugio Diffuso". Firstly, the study examined and compared various examples at the national and international level to a hypothesized a management model [29,31,33–44,46,65,68–70]. This model envisioned entrusting the management of the para-accommodation structure to third parties (private individuals). The purpose of this approach was to promote a management style driven by entrepreneurial incentive and ability.

The investment of the public administration in the purchase, renovation of the chalets, and recovery of the existing road network was approximately 1.15 million euros. In particular, for the "private" function of the widespread shelter, the potential annual demand was defined, and a concise financial plan was developed based on the functions that could be settled: 10 rooms for a total of 40 beds, common areas, and a bar/restaurant. The analysis of the demand revealed that the potential users of the structure were mainly school children (currently amounting to approximately 3000 visitors/year) along with nature-loving families and trekking tourists.

In summary, the manager's initial investment of 60,000.00 euros, consisting of 30% equity and 70% debt, covered the purchase of furnishings and equipment for rooms, common areas, and bar/restaurant premises. During the 20-year management phase, the cash flows became positive, starting from the second year, indicating a profitable investment.

In the FFP drafting, it was assumed that the manager started paying a rent of 9000.00 euros from the fifth year. In this way, the initial public investment was partially amortized.

The financial sustainability of the project, measured in terms of bankability, focuses on the project's ability to generate sufficient cash flows to guarantee the repayment of the acquired loans. This analysis involves two critical coverage ratios: the Debt Service Cover Ratio (DSCR) and the Loan Life Cover Ratio (LLCR). These ratios offer valuable insights into the project's capacity to meet its financial obligations and ensure long-term repayment of the loans.

In the specific case of the 'Rifugio Diffuso' project, both indices assume values well above unity (equilibrium point), indicating a strong financial position and sustainability:

- The DSCR was equal to 3.54 in the first period considered and increased to 4.39 in the last year of the loan (the 10th). This signifies that the project's cash flow was more than sufficient to cover its debt service obligations, providing a comfortable margin of safety.
- The LLCR was equal to 4.72 at the instant of evaluation and becomes 28.80 in the last year planned for the repayment of the loans. This indicates that the project's cash flow over its entire loan life was substantial, ensuring a robust ability to repay the loans in the long-term.

These high values for both the DSCR and LLCR demonstrate the project's strong financial health and its capacity to manage its financial obligations effectively throughout the duration of the loan.

8. Conclusions

Any plan for the physical reuse and functional adaptation of cultural heritage must necessarily find a balance between market demands, the cultural and social significance of the heritage to be revitalized, and the community's aspirations, respecting the identity of the asset and its urban context. In this decision-making context, this research presented a multi-level integrated methodology that supports the preliminary assessment of complex decisions [71] according to a multi-methodological approach aimed to facilitate a more informed decision-making process. The methodology was applied to a pilot project for the adaptive reuse of cultural heritage, specifically a group of mountain huts in the village of Lorica located in the Sila National Park (Italy).

The methodology, used in the preliminary stages of the project, integrated different tools and utilized various techniques from the field of economic estimation. The combination of integrated, qualitative, and quantitative methodologies, according a multi-phase approach [71], provided effective support to the Decision-Makers (DMs), guaranteeing objectivity in choices and transparent negotiation among the various stakeholders involved in the valorization and reuse of the cultural heritage [72] according to a transparent and rational framework for identifying shared solutions and intervention priorities.

The methodological framework provided support to DMs in defining priorities for intervention and actions based on a multidimensional and multi-criteria assessment for the definition of the most favorable alternative scenario, which was also verified from the point of view of its feasibility and sustainability. The adoption of this structured multi-methodological and integrated evaluation process offers valuable opportunities, particularly in economically vulnerable contexts such as the case study, where effective allocation of scarce resource is fundamental for the conservation of places and communities.

Integrated multi-methodological approaches are widely utilized in addressing complex decision-making problems across various domains of knowledge in accordance with the 2030 SDGs and European quality principles [73,74]. Their application proves particularly beneficial when making decisions regarding the adaptive reuse of cultural heritage, whether in the public or private sectors. These decisions involve a complex interplay between values and diverse, often conflicting interests, necessitating the establishment of a shared platform among Decision Makers (DMs), stakeholders, and the community [75,76] to define reuse projects conceived with the perspective of economic development in the relevant territory [76–79].

The model applied to the pilot project demonstrates the effectiveness of a transparent and comprehensible evaluative process that allows for a rapid assessment of the financial feasibility of the project using a Financial Feasibility Plan (FFP) and performance indicators based on the Discounted Cash Flow Analysis (DCFA). The evaluation process is thus an integral part of the project development process, serving as a support in the initial stages of assessing investment feasibility, optimizing investment choices, and facilitating the efficient allocation of public resources. The developed model focuses on "steady-state" cash flows. This simplification allows for the early identification of collective needs and any potential technical, procedural, and economic-management obstacles.

On the basis of the developed management hypotheses developed in the FFP, it is evident that the preliminary assessments of the economic and financial feasibility of the RD accommodation activity planned within the renovated cabins were thoroughly verified. The municipal administration, with this investment of general interest, committed to revitalize an abandoned hamlet with positive benefits for the entire community [80].

The results obtained from the application to the pilot project highlight the potential of a user-friendly and easily replicable model, even for less-experienced users. This model can be implemented as an additional verification of the evaluation criteria generated from more complex financial analyses.

Based on this application, it is possible to outline some future research paths. Firstly, the implementation of the model will be replicated in other pilot areas to increase its reliability. Secondly, a dynamic SWOT analysis [81] will be utilized in the model to provide more efficient support in structuring the decision problem with guidelines and strategic recommendations. Thirdly, through a more in-depth stakeholder analysis and sensitivity analysis for criteria elicitation, it will be possible to visualize different scenarios to test the robustness of the results in selecting the most favorable alternative.

In conclusion, it can be stated that the combination of different evaluation tools is highly promising in defining a framework that assists DMs in both the public and private sectors involved in the redevelopment and reuse of cultural heritage. This combination is also promising in the strategic evaluation of procedures to renew the vision of plans, programs, and projects for the enhancement of unused cultural heritage landscapes [82–84].

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Appendix A. The Technical Economic Framework for the Estimation of Investment Costs

(a1) Construction costs (architectural, plant, road, etc.)		€	800,000.00
(a2) Safety charges included in the works and not subject to a discount (2%)		€	16,000.00
(a3) Additional security charges (not subject to discount: 1%)		€	8000.00
(a4) Total auction-based works		**€**	**784,000.00**
(a5) Total contract amount		**€**	**808,000.00**
(b) Sums available to the contracting station			
(b1) Economical construction costs		€	-
(b1bis) Furnishings		€	-
(b2) Surveys and investigations		€	10,000.00
(b3) Connections to public services and urbanization works		€	40,400.00
(b4) Unexpected costs (% of a5)	5.0%	€	40,000.00
(b5) Acquisition of areas or properties		€	40,000.00
(b6) Provision for costs referred to to current regulations	1.0%	€	8080.00
(b6bis) Provision pursuant to procurement regulations	3.0%	€	24,240.00
(b7) Technical expenses for design and construction management	10.0%	€	80,800.00
(b7bis) Incentive fund pursuant to current regulations		€	12,120.00
(b8) Expenses for consultancy activities, etc.	1.5%	€	-
(b9–b10) Expenses for advertising, tenders, commissions, etc.		€	5000.00
(b11) Testing	1.5%	€	12,120.00
(b12) VAT on a5	10.0%	€	80,800.00
VAT on b4	10.0%	€	4040.00
VAT on b1bis	21.0%	€	-
VAT on b2	22.0%	€	2000.00
VAT on b7	22.0%	€	16,160.00
VAT on b7bis	22.0%	€	2424.00
VAT on b8	22.0%	€	-
VAT on b9–10	20.0%	€	1000.00
VAT on b11	22.0%	€	2424.00
		total €	341,608.00
Total investment cost		**€**	**1,149,608.00**

Appendix B

Years	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**…**	**10**	**15**	**16**	**17**	**18**	**19**	**20**
Rooms school groups	0	7.500	7.500	7.500	7.500	7.500	7.500	7.500	7.500		7.500	7.500	7.500	7.500	7.500	7.500	7.500
Double family rooms	0	9.000	9.900	10.800	11.700	11.700	11.700	11.700	11.700		11.700	11.700	11.700	11.700	11.700	11.700	11.700
Triple family rooms	0	11.250	12.375	13.500	14.625	14.625	14.625	14.625	14.625		14.625	14.625	14.625	14.625	14.625	14.625	14.625
Quadruple family rooms	0	13.500	14.850	16.200	17.550	17.550	17.550	17.550	17.550		17.550	17.550	17.550	17.550	17.550	17.550	17.550
Breakfasts	0	4.185	4.604	5.022	5.441	5.441	5.441	5.441	5.441		5.441	5.441	5.441	5.441	5.441	5.441	5.441
Lunches/dinners	0	13.950	15.345	16.740	18.135	18.135	18.135	18.135	18.135		18.135	18.135	18.135	18.135	18.135	18.135	18.135
User bar consumption	0	5.813	6.394	6.975	7.556	7.556	7.556	7.556	7.556		7.556	7.556	7.556	7.556	7.556	7.556	7.556
Bar drinks for passing users	0	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000		6.000	6.000	6.000	6.000	6.000	6.000	6.000
Total REVENUE	**0**	**71.198**	**76.967**	**82.737**	**88.507**	**88.507**	**88.507**	**88.507**	**88.507**		**88.507**	**88.507**	**88.507**	**88.507**	**88.507**	**88.507**	**88.507**
Investment costs	60.000	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Management costs:																	
- Personal	0	28.000	28.000	28.000	28.000	28.000	28.000	28.000	28.000		28.000	28.000	28.000	28.000	28.000	28.000	28.000
- Rental fee	0	0	0	0	0	9.000	9.000	9.000	9.000		9.000	9.000	9.000	9.000	9.000	9.000	9.000
- Electric energy	0	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	…	2.500	2.500	2.500	2.500	2.500	2.500	2.500
- Waterfall	0	650	650	650	650	650	650	650	650		650	650	650	650	650	650	650
- Heating	0	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000		3.000	3.000	3.000	3.000	3.000	3.000	3.000
- Advertising	0	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000		5.000	5.000	5.000	5.000	5.000	5.000	5.000
- Pantry-refreshment raw materials	0	8.984	9.703	10.421	11.140	11.140	11.140	11.140	11.140		11.140	11.140	11.140	11.140	11.140	11.140	11.140
Ordinary maintenance costs	0	1.500	1.500	1.500	1.500	1.500	3.000	3.000	3.000		3.000	4.500	4.500	4.500	4.500	4.500	4.500
Total COSTS	**0**	**49.634**	**50.353**	**51.071**	**51.790**	**60.790**	**62.290**	**62.290**	**62.290**		**62.290**	**63.790**	**63.790**	**63.790**	**63.790**	**63.790**	**63.790**
Provision for severance indemnity fund	0	2.333	2.333	2.333	2.333	2.333	2.333	2.333	2.333		2.333	2.333	2.333	2.333	2.333	2.333	2.333
Gross Operating Margin	0	19.230	24.281	29.333	34.384	25.384	23.884	23.884	23.884		23.884	22.384	22.384	22.384	22.384	22.384	22.384
Depreciation	0	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000		3.000	4.800	4.800	4.800	4.800	4.800	4.800
OPERATING INCOME	**0**	**16.230**	**21.281**	**26.333**	**31.384**	**22.384**	**20.884**	**20.884**	**20.884**		**20.884**	**17.584**	**17.584**	**17.584**	**17.584**	**17.584**	**17.584**
Net financial charges	0	149	151	153	155	182	187	187	187		187	191	191	191	191	191	191
Interest expense on investment	0	2.100	1.933	1.758	1.574	1.380	1.177	964	741		259	0	0	0	0	0	0
Interest expense on shareholder loans	0	1.260	1.134	1.008	882	756	630	504	378		126						

Years			**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	...	**10**	**15**	**16**	**17**	**18**	**19**	**20**
PROFIT BEFORE TAXES			**0**	**13.981**	**19.197**	**24.422**	**29.655**	**20.821**	**19.520**	**19.733**	**19.956**		**20.438**	**17.393**	**17.393**	**17.393**	**17.393**	**17.393**	**17.393**
Taxes			0	6.023	7.916	9.812	11.710	8.616	8.155	8.223	8.294		8.449	7.429	7.429	7.429	7.429	7.429	7.429
VAT recovery			0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
NET INCOME			**0**	**7.958**	**11.281**	**14.610**	**17.945**	**12.205**	**11.365**	**11.510**	**11.662**		**11.989**	**9.963**	**9.963**	**9.963**	**9.963**	**9.963**	**9.963**
depreciation (+)			0	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000		3.000	4.800	4.800	4.800	4.800	4.800	4.800
MOL NETTO			**−60.000**	**10.958**	**14.281**	**17.610**	**20.945**	**15.205**	**14.365**	**14.510**	**14.662**		**14.989**	**14.763**	**14.763**	**14.763**	**14.763**	**14.763**	**14.763**
Ordinary management income				71.198	76.967	82.737	88.507	88.507	88.507	88.507	88.507		88.507	88.507	88.507	88.507	88.507	88.507	88.507
Ordinary management exits																			
Mortgage principal repayment				55.476	55.904	56.323	56.734	65.442	66.617	66.278	65.928		65.195	66.314	66.314	66.314	66.314	66.314	66.314
Repayment of member loans (number of years)				3.339	3.506	3.681	3.866	4.059	4.262	4.475	4.699		5.180						
Cash flow (after tax)		**10**		1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800		1.800						
Ordinary management income				**4.559**	**7.841**	**11.120**	**14.397**	**8.591**	**7.673**	**7.731**	**7.785**		**7.883**	**14.763**	**14.763**	**14.763**	**14.763**	**14.763**	**14.763**
VAN	**90.413**																		
TIR	**6.10%**																		
WACC	**8.98%**																		
DSCR		**3.54**	**4.46**	**5.39**	**6.32**	**4.67**	**4.39**	**4.39**	**4.39**	**4.39**	**4.39**								
LLCR	**4.72**	**5.59**	**6.15**	**6.71**	**7.28**	**7.84**	**9.11**	**11.32**	**15.7**	**28.8**	**-**								

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Article

Analysis of Passive Strategies in Traditional Vernacular Architecture

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Abstract: Vernacular architecture constitutes a rich source of information and ancestral knowledge and could become a key resource for sustainable development. Its passive design strategies effectively respond to local climatic and weather conditions, using locally sourced materials for the construction of its supporting structures and enveloping elements, as well as spatial organization and the incorporation of a buffer area (courtyard) that optimize the use of renewable resources. This qualitative study analyzes a traditional housing typology with a central courtyard located in the Historic Center of Azogues, Ecuador. In situ monitoring was conducted to evaluate the case study's interior thermal comfort in different building spaces. Using the open-source software Open Studio and EnergyPlus, a simulation model was built to assess the annual thermal performance of the house. Field records were used to verify the effectiveness of the strategies that responded to the location's climatic conditions. The analysis of the passive strategies used in the selected house included natural ventilation, solar protection, and thermal insulation, which depended on various aspects of the building, such as its location, the internal space's arrangement, and the design of openings (doors and windows), among others. The thermal simulations revealed that the traditional house located in the Historic Center of Azogues was well adapted to the local climate, although the interior thermal comfort was not entirely satisfactory.

Keywords: vernacular housing; passive design strategies; indoor thermal environment; building energy performance; dynamic thermal simulations

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1. Introduction

During the past several decades, the increasing energy consumption in the building industry has reached approximately 40% of the global energy consumption [1]. This figure is expected to further increase due to demands for improved quality of life and population growth, which will require larger areas for urbanization [2]. This growth model in the building industry has contributed to the depletion of energy resources and the exacerbation of global warming [3]. However, over the last decade, the industry has undergone a paradigm shift, with growing environmental awareness and recognition of the issues related to energy efficiency and environmental impacts [4]. Therefore, buildings play a key role as their passive design, which adapts to local climatic conditions and minimizes the use of mechanical systems for climate control, is crucial in reducing the energy demands of buildings without compromising the comfort of their indoor environments [5,6].

Vernacular buildings are constructed using local materials and designed with passive strategies, allowing them to adapt to the local climate. Due to the economic limitations of their owners and the thermal adaptability of their spaces, residents rely on the building's passive capacity for thermal comfort [7]. There are various typologies of vernacular buildings according to the climate and region of implementation, which serve as useful examples for the achievement of sustainability through architectural design and reducing the reliance on artificial climate control and its subsequent energy [5,8–10]. Currently, some scholars and researchers are investigating how vernacular techniques and materials can play a decisive role in creating more sustainable and energy-efficient buildings [11,12]. Therefore, knowledge of vernacular construction could be relevant not only for the conservation and restoration of existing heritage buildings but also for the construction of new sustainable and resilient buildings in the future [9].

Despite the growing interest in energy simulations and quantitative results, few studies have focused on this area. One such study focused on vernacular housing in the village of Xinye, China, conducted by Gou et al. [8]. The study demonstrated that annual thermal comfort simulations could be obtained with the support of the EnergyPlus simulation engine, using on-site monitoring and data collection over short periods of time. Additionally, the study identified passive strategies implemented in the building that improved the thermal comfort during hot summers, although they were less effective during cold winters. Similarly, the study by Cardinale et al. [11], focused on the energy and indoor comfort of vernacular architecture in Sassi and Trulli (Southern Italy), experimentally analyzed a dwelling in each site through the interior and exterior monitoring of environmental parameters, the in situ measurement of material properties, and simulation using EnergyPlus. This analytical methodology demonstrated that the experimental phases and subsequent simulation are crucial for buildings characterized by uncertainty and complexity. Numerical simulations of the annual thermal performance of the dwellings were obtained, indicating that the buildings did not require air conditioning during summer and that simple heating systems could ensure comfort levels during winter.

Another study aimed to analyze the site-specific strategies, thermal performance, and comfort conditions of a vernacular building in Southern Portugal. This was achieved through both objective and subjective indoor measurements taken for one day per season and long-term outdoor measurements. This study demonstrated the effective thermal performance achieved solely through passive strategies during periods of heat waves [4].

This research focuses on an existing vernacular dwelling in the city of Azogues, Ecuador. It involves environmental monitoring, in situ measurements, and dynamic simulations to collect data on the house's indoor thermal performance. Using the EnergyPlus engine, simulation results are obtained and used to evaluate the effectiveness of the passive design strategies inherent in this type of building, which can be applied to new buildings in order to achieve sustainability [13,14].

1.1. Research Site

The case study of this investigation is a vernacular house located in the Historic Center of the city of Azogues (Figure 1), in the southern inter-Andean region of Ecuador (−2.73969, −78.8486), with an altitude of 2518 masl (meters above sea level). Azogues has been recognized as a cultural and urban heritage site in Ecuador since 31 October 2000. The city is bounded to the north by the provinces of Chimborazo and Morona Santiago, to the east and south by the province of Azuay, and to the west by the cantons of Déleg and Biblián. The area of study was selected due the historical and cultural importance of the city, as well as the potential for this vernacular architecture to guide sustainable design strategies for new buildings.

The central subject of this research is a vernacular house with a central courtyard typology. The courtyard is used as a central axis upon which other spaces of the building are distributed. The adjacent orchard provides a space for outdoor activities throughout the different seasons of the year. Factors such as air temperature, relative humidity, and wind speed significantly impact the comfort and well-being of its residents; therefore, this research examines the correlation between the passive design strategies utilized during the building's construction and its response to weather conditions. This house, along with others, has played a significant role in the declaration of the area as a cultural heritage site. Consequently, it is crucial to examine this traditional model from the perspective of passive design strategies. Previous research has shown that incorporating vernacular architecture is vital in achieving sustainability in contemporary architectural practices. Furthermore, studying and analyzing such architectural styles can provide a viable approach for the upcoming generation of architects to promote sustainable design [15].

Figure 1. Azogues city location.

1.1.1. Weather

The city of Azogues is surrounded by several hills, such as Blanca, Chavay, Toray, San Pedro, Shigshiquin, Guabzhumbuil, and the Cojitambo and Abuga hills. The Burgay River forms a natural semicircle, creating a highly scenic backdrop that defines the silhouette and physiognomy of Azogues. Additionally, the group of ravines, such as the Shirincay and the banks of the Tabacay River, located within the urban area, hold significant potential as tourist attractions. These natural features contribute to an environmental framework that ensures the future quality of life of the population in a sustainable and high-quality environment. It is worth noting that these natural elements possess extraordinary historical, cosmogonical, and totemic value, as each of them serves as a religious and worship center, which are fundamental to the Cañari cosmogony and the city's cultural identity.

The climate of Azogues is strongly influenced by its natural surroundings. The prevailing wind blows from the east year-round (Figure 2). The windiest month in Azogues is July, with an average wind speed of 15.3 km per hour, while the calmest month is November, with an average wind speed of 6.8 km per hour [16]. The city's northward orientation can benefit from natural ventilation.

Table 1 presents the climatic data for Azogues. The monthly average temperature peaks at 13 °C in March and April and drops to 8 °C in July and August. The month with the highest rainfall is March, with average precipitation of 94.8 mm, while the month with the lowest rainfall is August, with an average of 23.10 mm.

In terms of the duration of the day, there is no significant variation throughout the year, with an only 17-min variation in 12 h. For the year 2022, it was found that the shortest day was June 21st, with 11 h and 58 min of natural light, while the longest day was December 21st, with 12 h and 17 min of natural light.

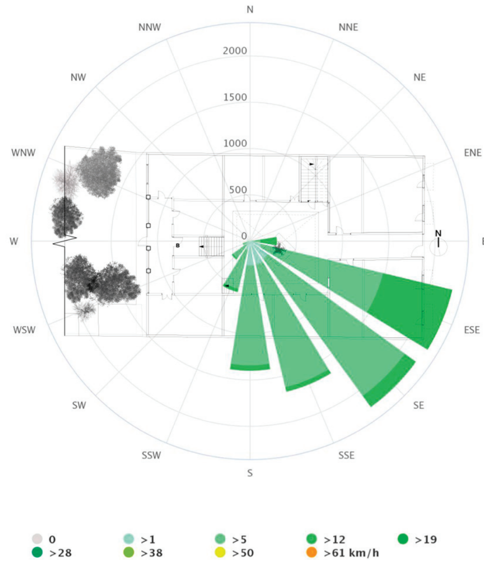


Figure 2. Wind rose for the city of Azogues [17].

Table 1. The climatic data for the city of Azogues [16].

Month	January	February	March	April	May	June	July	August	September	October	November	December
Average temperature °C	12	12	13	13	11	9	8	8	9	10	11	11
Maximum temperature °C	15	15	16	16	14	11	10	10	12	12	13	14
Minimum temperature °C	9	10	10	10	9	7	6	6	7	8	8	9
Rain (mm)	53.1	80.8	94.8	78.2	56.4	43.3	28.3	23.1	31.1	51.1	50.8	52.9
Rainy days	11.7	14.6	17.5.	15.5	12.1	9.6	7.5	6.3	8.1	11.6	10.9	11.3
Hours of sun	12.3	12.2	12.1	12.0	12.0	12.0	12.0	12.0	12.1	12.2	12.2	12.3

1.1.2. Description of the Traditional Dwelling

On 31 October 2000, Azogues was designated as one of Ecuador's 38 cities recognized as heritage sites due to its remarkable architectural, urban, and scenic qualities. In order to achieve this distinction, a total of 135 real estate assets that contributed to the region's religious and civic architectural heritage, as well as eight urban architectural complexes that possessed notable formal, constructive, and typological features, were inventoried.

The Ministry of Education and Culture's 2000 report on the declaration of Azogues as a heritage site reveals that the buildings date back to the late 19th and early 20th centuries [18].

1.1.3. Typologies of Traditional Houses

One of the architectural forms of the traditional buildings existing in the city of Azogues, as shown in Figure 3a,c, is the house with a "central courtyard," which recalls or commemorates the cities conquered by the Spanish since their urban organization was based on the "Plaza Mayor." Other typologies of traditional houses are in the shape of an "L," since the courtyard is displaced to one side of the land, thus providing access to the house through a corridor (Figure 3b). All spaces around the courtyard are generally composed of two floors.

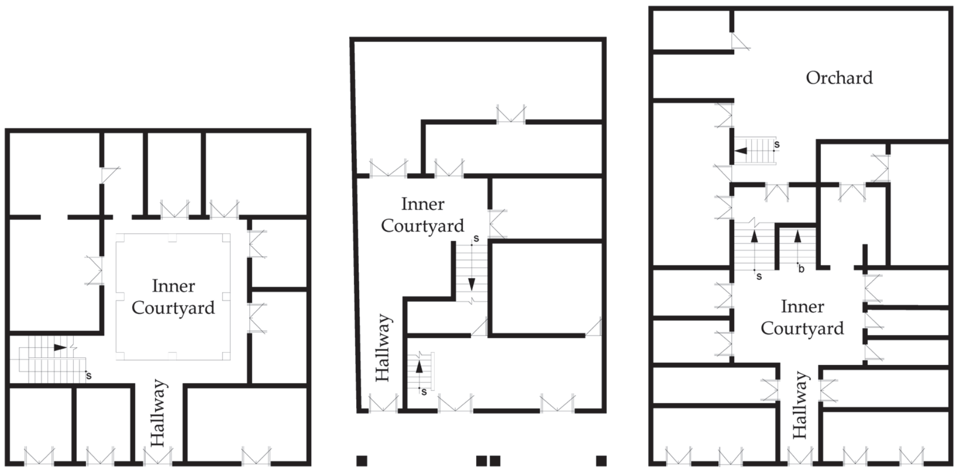


Figure 3. Typologies of traditional houses. (**a**) house with a "central courtyard", (**b**) an "L" shaped house, (**c**) a house with a "central courtyard" and orchard at the back.

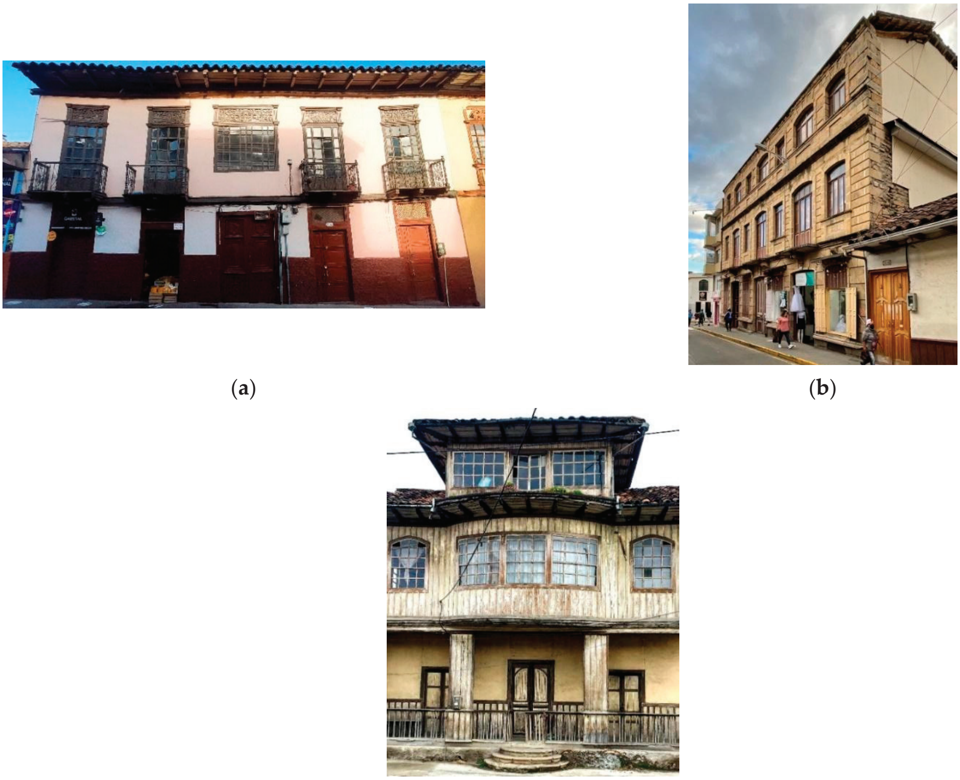
Ground floors are typically dedicated to commercial activities and have a direct connection to the street and interior courtyard. However, there are also completely independent commercial spaces that suggest that they were intended for rent. The living and dining rooms are the main spaces where people socialize and gather. They are also used for special events at different times of the year.

Most buildings with "courtyards" function as "light wells"—a central or lateral area connecting the main entrance to the courtyard. Due to the city's topography, subsurface areas are often generated, which require strong retaining walls composed of river stones and structural solutions using wood [18].

Buildings with a "central courtyard" were typically owned by affluent families. It was common for such houses to have monoculture gardens and fruit trees at the rear of the property, similar to the case study for this research (Figure 3c). These areas provide an opportunity for inhabitants to switch their outdoor activities to different locations throughout the various seasons of the year.

Residential buildings in Azogues commonly use bahareque walls, a building system that protects the interior environment from climatic variations throughout the year (as shown in Figure 4a). The external walls also utilize this technology, with some facades constructed with stone (as shown in Figure 4b) and wood (as shown in Figure 4c). The combination of envelope systems and a tilted roof constructed with wood and clay tiles enhances the building's thermal insulation properties. The traditional dwelling depicted in Figure 4a, which is the focus of this study, has an external envelope with a thickness of 17 cm and internal walls of equal thickness. As detailed in Section 4, on-site measurements were conducted to assess the thermal performance of the building envelope. The analysis of the collected data revealed that this particular envelope system effectively reduces the effects of severe weather conditions on the interior thermal comfort.

The main facade's wall is composed of "bahareque." Bahareque is the name of a construction system for houses, in which sticks, canes, reeds, "cabuya," and mud are used. The main wall plays a very important role as the closure of the building, which is commonly decorated with wooden slats that highlight the plinth but are also used in other parts of the façade, such as the window sills. The levels of the building are differentiated with the use of very simple borders, and the window openings are framed with wood moldings topped with perforated wooden or brass plates.



(**a**) (**b**)

(**c**)

Figure 4. Types of building envelopes found in the facades of heritage houses in the city of Azogues. (**a**) house with bahareque walls, (**b**) house with stone facade, (**c**) house with wooden facade.

Most of the houses' interior walls are also built of bahareque, resting on a foundation composed of rounded stones that transmit the load of the construction to the ground. Mud mortar is commonly used as a coating, and a refined layer is applied to both the outer and inner surfaces of the wall, enhancing its aesthetic appeal. The tilted roofs of the houses are usually composed of wood and are generally covered with handmade burnt clay tiles.

1.1.4. Openings' Design

In Azogues, the placement of building openings such as windows and doors disregards the local climatic conditions, specifically the dominant wind directions. The majority of dwellings in the area feature windows positioned on the primary facades, typically spanning from floor to ceiling and divided into multiple sections, which are complemented by balconies lacking corbels and bearing wrought iron or wooden balusters. As the local wind predominantly comes from the east, windows improve the natural ventilation, particularly in buildings oriented towards the windward side. Furthermore, a notable window-to-wall ratio is another feature of passive building design that can enhance the thermal performance of the structure. Figure 5a illustrates that the bedrooms and commercial spaces located towards the main street lack windows. It can be noted that the main entrance door of the dwelling has significant height in comparison to the other doors of the building and is located in the center of the main facade, which also helps to improve the natural ventilation conditions within the dwelling.

(a) (b)

(c)

Figure 5. Internal images of the selected building for the study. (**a**) west facing gallery, (**b**) galleries facing the main street and north, (**c**) gallery facing the main street.

1.1.5. The Buffer Space

The traditional homes in Azogues are characterized by an inner courtyard, a space that is connected to the exterior through an alleyway (zaguán) and to the other internal spaces, providing a feeling of comfort. The courtyard is designed with the intention of facilitating movement and promoting air circulation within the building. The presence of a fountain further aids in cooling the air, contributing to an improved climatic environment in this specific area of the residence. The courtyard can also be considered an open buffering space that directly influences the natural ventilation and lighting in the building, contributing to protecting the interior spaces from strong solar radiation [19]. Semi-open spaces such as galleries and "zaguáns," which connect the interior and exterior areas of the home, can be crucial to the effectiveness of natural ventilation.

2. Materials and Methods

The research's methodological design was based on Gou et al. [8], who proposed an experimental investigation grounded in the case study approach. This approach involved analyzing the construction technique of the building within the context of its normal use and occupancy. Direct observations were performed of the object of study in its context, with the aim of obtaining the maximum amount of information in situ. In this study, equipment was used to record data on the wind speed, relative humidity, wind direction, and the envelope's temperature. The measurements of the outdoor environmental parameters were correlated with the indoor comfort parameters, considering the following comfort ranges: air temperature 17–22 °C, relative humidity 40–65%, and air velocity <0.2 m/s [20].

For the research's development, electronic measuring instruments that met the requirements of objectivity, validity, and reliability were used, such as HOBO for data collection on temperature and relative humidity, Testo 435 to obtain data on the surface temperature of the building envelope, and Anemometer Testo 435 to measure the wind speed. Templates were developed for data tabulation and figure creation for data processing.

Based on previous studies on this topic, the following four-stage methodological design was proposed for the case study.

Stage 1—Selection and Planimetric Survey of the House: The research began with the selection of a house through the review of existing documentation on the inventory of heritage properties in the city of Azogues, based on the following criteria.

- A habitable house with traditional vernacular characteristics and a spatial organization typology consisting of a central courtyard and garden.
- The house should not have been renovated and should maintain its original spatial characteristics and construction systems.
- To assess the interior thermal environment, on-site monitoring provides accessibility, while energy simulations enable the evaluation of the building's performance.
- Once the house was selected, a visit was made to verify its physical–spatial characteristics, to validate the reasons that it was included in the inventory as a heritage property. Subsequently, the owners of the property were approached to request their authorization for the planimetric survey of the house and the placement of the registration equipment inside it.

Stage 2—Data Collection In Situ: Data collection was performed by installing equipment in different areas of the building, such as the HOBO U12 Temp/RH. Data loggers were utilized to measure and record the temperature and relative humidity, wind speed (Testo anemometer), surface temperature of envelope materials (Testo 635 surface thermometer), and wind direction (smoke tracers).

Stage 3—Data Processing: The data from Stage 2 were used to generate tables and figures for the analysis and comparison of the different monitored environments and their behaviors in response to local climate phenomena.

Stage 4—Evaluation of the Thermal Performance of the Building: The thermal performance was evaluated using the software SketchUp for modeling and the open-source software Open Studio with EnergyPlus for simulation. The model was validated with the monitored data collected from different points within the building to determine its annual thermal performance.

2.1. Description of the Studied Dwelling

The building was constructed in 1910 and it has preserved its original form, and no alterations or modifications have been observed throughout the years. The house inherited construction techniques and design methods that were passed down from generation to generation. It is one of the most typical house designs in Azogues, consisting of a central courtyard and garden oriented towards the east, with four galleries in which the different spaces are distributed. The areas designated for the living and dining rooms are located on the upper floor of the building, in the gallery that faces the main street (Figure 5c). The monitoring of the thermal comfort data primarily focused on the various galleries present within the dwelling, as they exhibit climate-sensitive characteristics.

The gallery facing west (Figure 5a) is topped by a lookout that is accessed through a staircase located on the rear facade of the building.

The selected house (Figure 6) includes surrounding corridors to the central courtyard on both the ground and upper floors, in such a way that the interior spaces benefit from natural lighting. Resting areas such as bedrooms are arranged on the north and south sides of the building. The basic idea of the courtyard consists of forming an enclosed space protected from the outside, where it is possible to control the climate, creating a differentiated, regular, and daily cyclic microclimate that benefits the house [21], providing the bedrooms with optimal cross-ventilation. Furthermore, the strategic placement of rooms on the north and south sides of the building adds an additional benefit from the shade, effectively reducing the direct solar heat gain during hot periods.

Figure 6. Plan views of the chosen representative residence, displaying the positions where data monitoring took place.

2.2. Experimental Setup

The experimental setup was based on the methodology introduced by Gou et al. (2015) [8]. The thermal comfort monitoring was conducted from 2nd July 2022 to 3 July 2022, which is the month in which Azogues city experiences the lowest temperatures of the year, ranging from 6 °C to 10 °C. The monitored data encompassed the air temperature, relative humidity, wall surface temperature, and wind speed. A HOBO data logger was employed to automatically capture air temperature and relative humidity data at 10-min intervals. Wall surface temperature and wind speed data, on the other hand, were manually collected once per hour throughout the evaluation period. The technical specifications of the data collection instruments utilized are provided in Table 2. It is worth mentioning that the equipment employed was certified by the manufacturer.

Table 2. Technical specifications of measurement instruments.

Parameters	Instrument	Measurement Range	Accuracy	Resolution
Air Temperature/Relative Humidity	HOBO MX1101 Temperature/Relative Humidity Data Logger	−20 °C to 70 °C	±0.2 °C and ±2%RH	0.024 °C at 25 °C 0.01%RH
Wall U-Value	Testo 635-1 and temperature probe to determine U-value	−20 °C to +70 °C	±(0.1 °C + 0.2% of mv)	0.01 W/m^2 K
Wind Speed	Testo 410-2 Vane anemometer	0.4 m/s to 20 m/s	±(0.2 m/s + 2% of mv)	0.1 m/s

2.3. Measurement Areas

Figure 6 shows the five locations within the house that were selected for the monitoring of the air temperature and relative humidity: bedroom 7, the central courtyard, the rear vestibule facing the garden, the mezzanine room, and the main living room. All measurement points were established at a height of 1.5 m above ground level. Suitable devices were employed to record exterior data throughout the measurement period. The surface temperatures of the monitored building envelope in bedroom 7 of the north gallery are not identified in Figure 6. Data collection points were positioned 1.5 m above ground level at the center of both the external and internal surfaces of the walls.

Two methods were employed to measure the wind speed. The first one involved placing a recorder in the gallery situated in the eastern part of the building, near the window of the living room. Data were manually recorded every hour to determine the wind direction using smoke tracers simultaneously. The second method comprised conducting short-term measurements at three distinct points, as illustrated in Figure 6 (central courtyard, doors A and C), to understand the natural ventilation behavior of the house.

A summary of the experimental conditions for short-term data monitoring is presented in Table 3. Wind speeds were manually measured and recorded at consistent intervals of 30 s, while smoke tracers were synchronously employed to determine the wind direction.

Table 3. Short-term experimental tests of natural ventilation in the building.

Experiment	Experimental Conditions	Location of Experimental Points	Experiment Duration
1	Doors A, B, and C were opened, while all other doors were closed.	Door A and C	10:00:00–10:15:00
2	All doors were closed except for Door A.	Door A and central courtyard	15:00:00–15:15:00
3	Doors A, B, and C were opened, while all other doors were closed.	Door A, central courtyard, and Door C	19:30:00–19:40:00

3. Results and Discussion

3.1. Indoor Environment Monitoring

Measurements of speed were taken three times during the day at short intervals, with the purpose of evaluating the building's natural airflow and ventilation. The wind direction was recorded using smoke tracers located at the points indicated in Figure 6, simultaneously. The experiments, their conditions, and the locations of the sensors for wind speed data collection are described as follows.

Experiment 1 involved measuring data at doors A and C, while doors A, B, and C remained open, and all other doors were closed. This experiment revealed that during the 15-min sampling period in the morning, the wind at door A originated from the west, while, at door C, it changed direction to the east. The wind speed at door A exhibited significant strength, averaging 1.35 m/s, whereas, at door C, it was approximately 0.81 m/s (Figures 7 and 8).

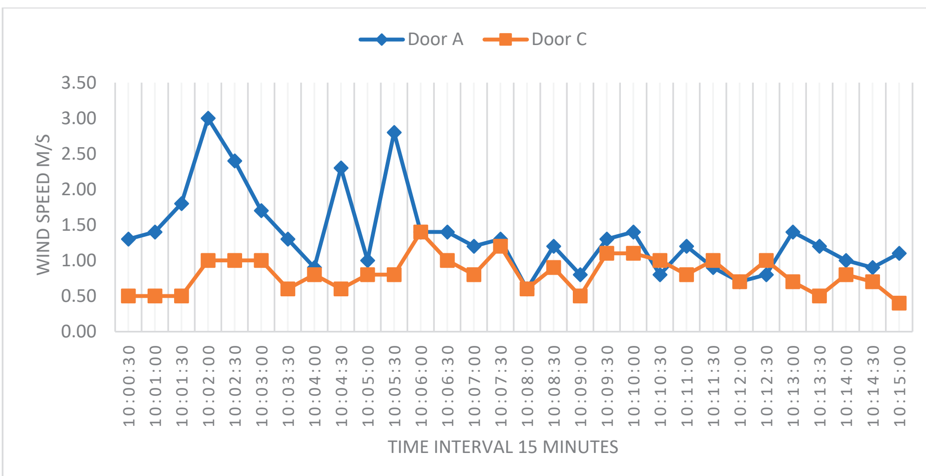


Figure 7. Short-term variation in wind speed monitored during the morning.

Door A Door C

Figure 8. Smoke tracer for determination of wind direction during the morning.

During the second experiment, data were recorded in the afternoon for a sampling period of 15 min. The test involved closing all doors except for door "A", and measurements were taken at door "A" and in the central courtyard. The recordings revealed that the wind in the central courtyard had an upward direction, while, at door "A", the wind had a west–east direction. Additionally, in this experiment, it was found that the wind at door

"A" had an average velocity of 0.88 m/s, with a recorded maximum of 2.20 m/s during the sampling period. The wind speed in the central courtyard was much lower, with an average of 0.48 m/s (Figures 9 and 10).

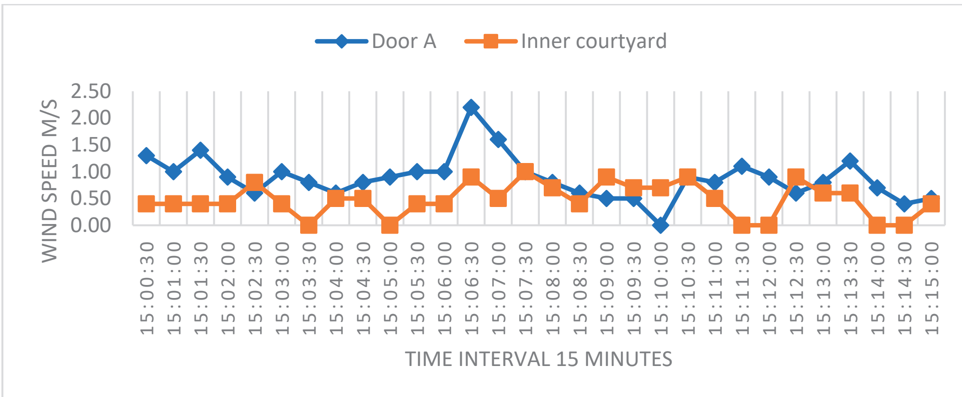
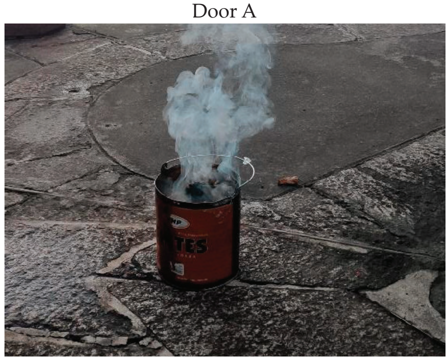


Figure 9. Short-term variation in wind speed monitored during the afternoon.

Door A



Door C

Figure 10. Smoke tracer for determination of wind direction during the afternoon.

Experiment 3 was conducted at night for 10 min to evaluate the natural ventilation of the building. The experimental conditions were the same as in experiment 1, with measurements taken at door A, the central courtyard, and door C. The wind direction was found to be west–east at both door A and door C, while an upward direction was observed in the central courtyard. The average wind speed at door A was recorded as 0.91 m/s, while, at door C, it was measured to be 0.80 m/s., while the average speed in the central courtyard was 0.41 m/s (Figures 11 and 12). These findings provide insight pertaining to the natural airflow and ventilation within the building during nighttime.

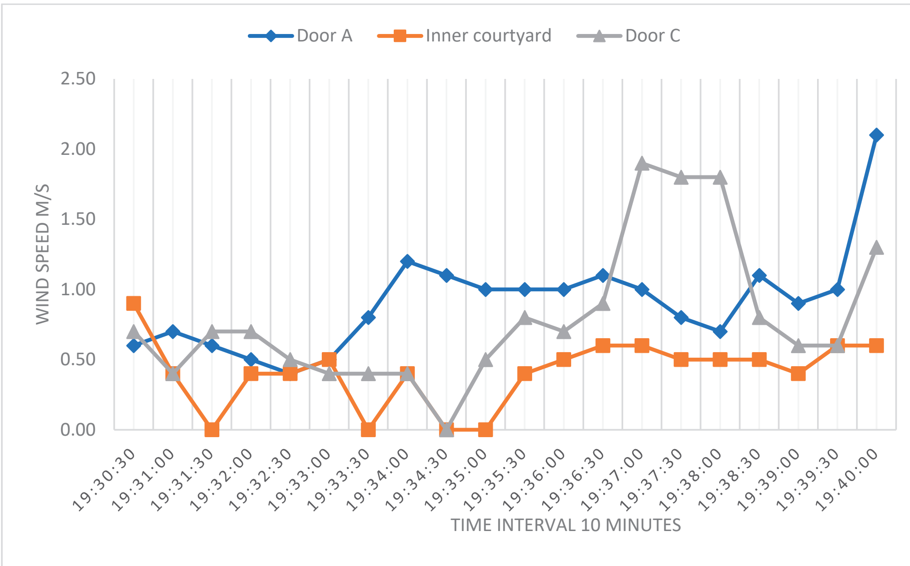


Figure 11. Short-term variation in wind speed monitored during the night.

Door A

Buffer space

Door C

Figure 12. Smoke tracer used to determine wind direction during the night.

The experimental tests (2 and 3) show that the predominant local wind comes from the west–east direction, and this wind stream can be regarded as the main source of natural ventilation within the house. However, according to test 1, the predominant local wind takes two directions, west to east (door A) and east to west (door C), during the morning. The courtyard functions as an outlet for air circulation, while the windows and doors serve as inlet openings for fresh air intake; the smoke tracers placed in the central courtyard showed that the natural ventilation during the morning, afternoon, and night was upward, producing a chimney effect. Nevertheless, it is noteworthy that the main room of the building, where a wind speed recorder was placed despite being oriented in the predominant wind direction, recorded an average speed of 0.39 m/s, which can be considered imperceptible. This observation is supported by the smoke tracer images placed in the main room (Figure 13).

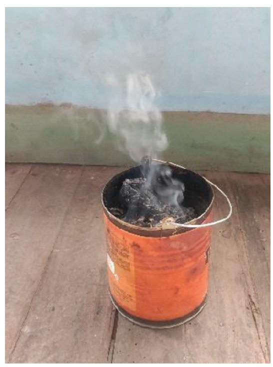


Figure 13. Smoke tracer for determination of wind direction in the main hall.

The air temperature profiles shown in Figure 14 demonstrate that the outdoor temperature exhibited a diurnal variation of 6.96 °C (i.e., ranging from 8.80 °C to 15.16 °C), while the temperature recorded in the main room fluctuated between 15.11 °C and 17.05 °C, displaying a diurnal variation of 1.94 °C over the same time period. The central courtyard had an average temperature of 14.92 °C, and the temperature inside the building was higher than the outdoor temperature, whereas the outdoor temperature was 1.67 °C lower than that of the rear vestibule. It is evident that the temperature variations in the mezzanine room and bedroom 7 coincided throughout the monitoring period. The mezzanine room was approximately 0.23 °C warmer than bedroom 7, while the main room was 1.26 °C hotter than bedroom 7 during the day. At night, bedroom 7 was slightly cooler than the main room, with a difference of 0.30 °C.

The relative humidity (RH) levels in the central courtyard, as depicted in Figure 15, exhibited the most fluctuation among the interior values (i.e., varying from 59.03% to 85.43%). The relative humidity in bedroom 7 was the most stable (i.e., varying by only 1.93%, from 67.23% to 69.15%), while the highest value (around 88.86%) was observed in the rear vestibule during the monitoring period. It is important to note that while the temperature in bedroom 7 was lower than in the main room during nighttime, the former exhibited lower relative humidity values, indicating a drier environment compared to the latter. Based on the monitoring results, bedroom 7 was the coolest place in the house. This phenomenon can be attributed to the fact that bedroom 7 was enclosed by three solid walls and had only one connection to the exterior (central courtyard) through a door. As a result, natural ventilation in this area was restricted. However, the room benefitted from effective shading, reducing the influence of the outdoor air temperature and solar radiation.

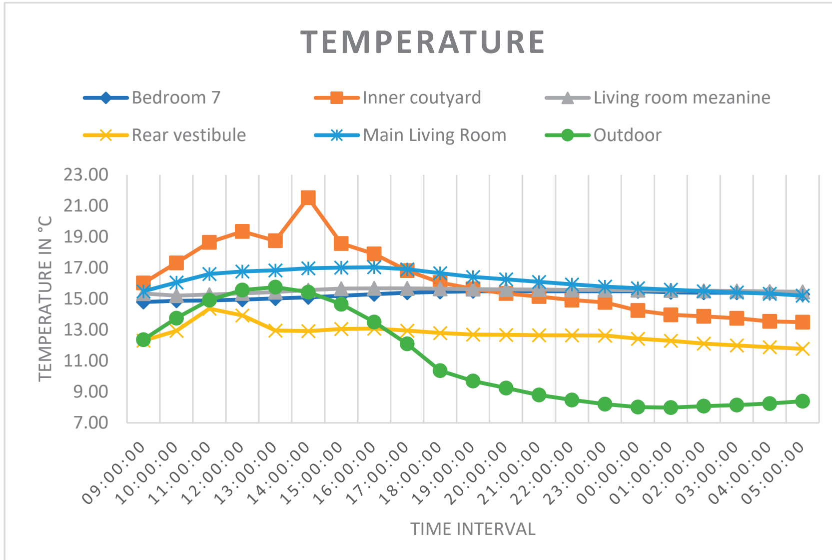


Figure 14. Variation in air temperature at diverse monitoring points.

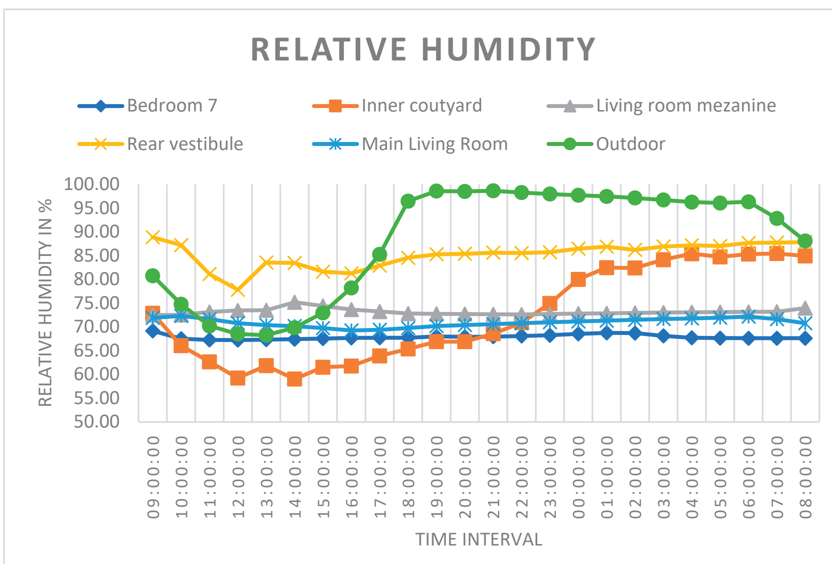


Figure 15. Variation in relative humidity at diverse monitoring points.

The air temperature in the rear vestibule was the coldest in the house. Moreover, this space was the most humid, despite having good natural ventilation. This behavior can be attributed to the fact that this environment is located at a lower level with respect to the street level, and its enclosing structure is composed of wooden partitioning. According to the monitoring results, the relative humidity in the mezzanine room was the most constant among all the rooms in the house. However, it was cooler than the main room.

The temperature profiles of the internal wall surfaces in bedroom 7 are presented in Figure 16. The results show that the west wall surface has the largest diurnal variation of 1.4 °C (i.e., from 17.00 °C to 18.40 °C), while the east wall surface has the lowest variation at night (i.e., 0.10 °C from 15.30 °C to 15.40 °C). The north wall surface maintains a stable temperature at 15.50 °C during the night. The internal south wall surface records the lowest average temperature during the night at 14.92 °C, while the external surface records 15.00 °C, with a variation of 0.08 °C. The temperature of the internal wall surfaces in bedroom 7 is higher than the external temperature; this can be attributed to the thermal insulation and thermal mass properties of the walls, which contribute to the observed effects.

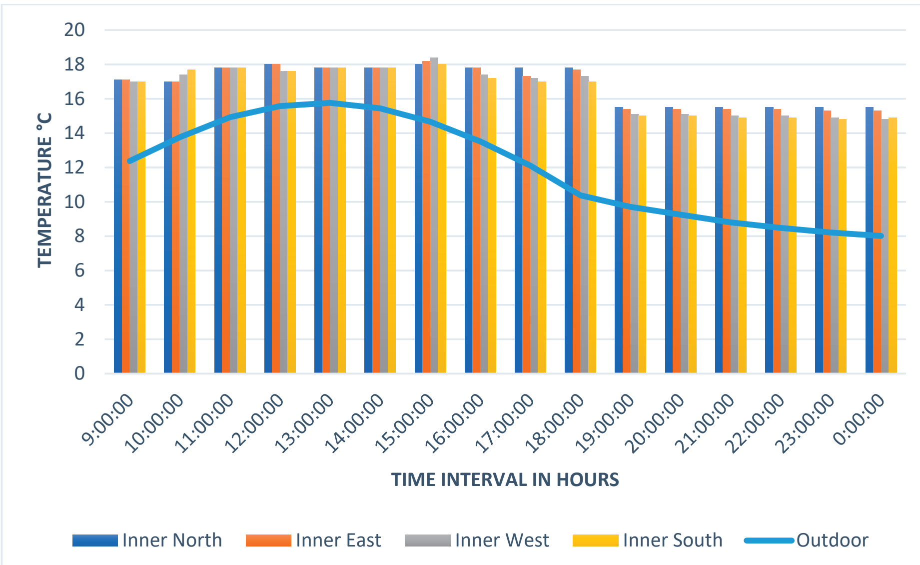


Figure 16. Variation in surface temperature of envelopes in bedroom 7.

3.2. Thermal Performance Simulation

In order to identify whether there were environmental improvements in the case study, a thermodynamic performance analysis was performed. Firstly, a model of the current state of the building was obtained through the EnergyPlus/Open Studio graphic interface [22]. The data were collected through planimetric measurements of the building, as there were no existing records due to its age. In the model, all thermophysical properties of the building's envelope were defined (Table 4). The values of the opaque envelope were taken in situ using the Testo 635 Surface Thermometer tool, and for the transparent envelope (and other materials that could not be measured), the values were taken from the Ecuadorian Construction Standard [23]. Additionally, usage schedules and profiles were defined for a home with an average occupancy of three people (current number of occupants), an internal load with lighting power of 11.62 W/m^2, and electrical equipment of 48 W/m^2. The analysis was conducted in the absence of an air conditioning system, which is typical for residential buildings in the studied area. Consequently, the behavior of the building under external climatic conditions was the focus of the study. Finally, we inputted meteorological data for an entire year from the weather station located 3 km from the building (identified as DX300 HOBO). EnergyPlus was then used for energy calculations and Radiance was used to simulate the thermodynamic performance. To ensure the reliability of the simulation results, the model was validated (Figure 17) through the calibration of the model with a comparison process between experimental data taken during the monitoring of the interior environment of the living room and the simulation results.

Table 4. Thermophysical parameters of the simulated building.

Building Envelope Component	Thickness (m)	Thermal Conductivity (W/Km)	Density (kg/m^3)	Specific Heat (J/kgK)	U Factor (W/m^{2}K)
Interior Bahareque Wall	0.17	1.28	1460	880	3.48
Exterior Bahareque Wall	0.17	1.28	1460	880	3.48
Upper Wood Floor	0.21	0.13	840	1381	0.02
Ground Wood Floor	0.21	0.13	840	1381	0.3
Interior Wood Ceiling	0.015	0.13	840	1381	0.02
Clay Tile	0.015	1.00	2000	800	3.22
Wood Door	0.06	0.19	700	2390	1.59
Exterior Wood Window	0.06	0.19	700	2390	1.59
Interior Glass Window		Thickness (m)	U-Factor (W/m^2 K)	Glass SHGC	Clear glass Transmitance
Interior Glass Window		0.004	5.781	0.862	0.898

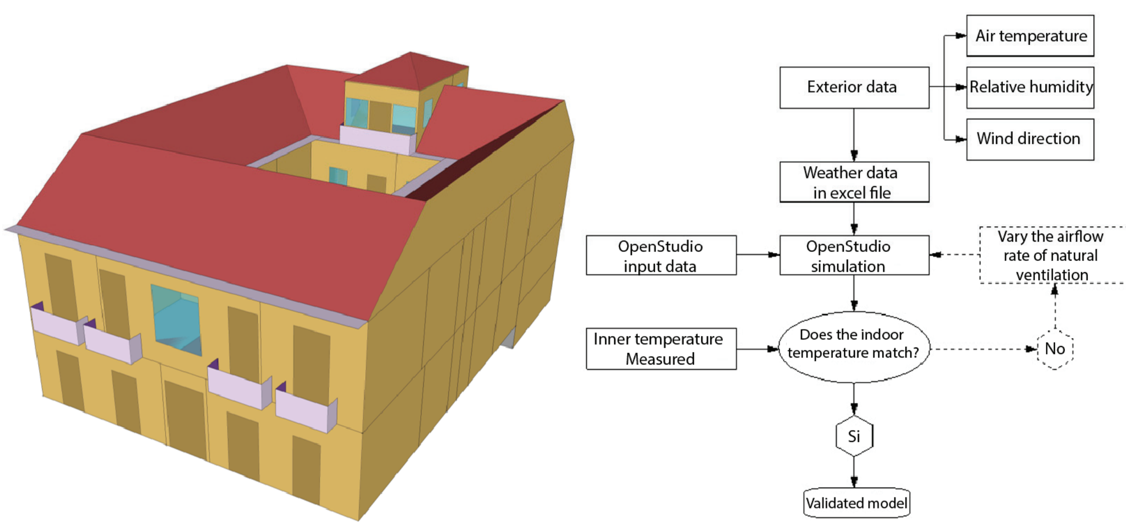


Figure 17. Constructed simulation model and model validation procedure.

Model Validation

The validation was based on the model calibration process through the comparison of monitored and simulated data from the living room. Nowadays, this is frequently used in research as a means of validating results by calibrating the model through the comparison of monitored data in short periods of time and building simulations to identify thermal comfort and energy benefits [8,24–26]. Monitored data at various points in the building were used for model calibration (Figure 6). The indoor air temperature of the main room was used as the parameter for model validation, given its strong connection to the thermal environment of the entire building. The simulated temperature in the main room was compared to the values recorded during observation periods (Figure 18). The comparison evaluated indicators used by the scientific community and defined by international organizations such as the American Society of Heating, Refrigerating and Air Conditioning (ASHRAE) and the National Renewable Energy Laboratory (NREL) [27], which establish acceptable ranges for statistical calibration rates. After calibration, hourly and monthly simulation data for an entire year could be obtained. A model is considered valid if the difference between the simulated and monitored values falls within the acceptable range defined by international standards (RMSE 10% and NBME 25%) [28,29]. Two well-accepted statistical indicators for model validation are the normalized mean bias error (NBME) and the root mean square error of the bias (RMSE). To assess the correlation between the simulation and monitoring results, specific criteria were adopted. These criteria are formally defined as follows:

$$NMBE\left(\frac{0}{0}\right) = \frac{\sum_{i=1}^{n}\left(t_{ip} - t_{mi}\right)}{n-1} \times \frac{1}{\underline{t_m}} \times 100$$

$$CV(RMSE)\left(\frac{0}{0}\right) = \sqrt{\frac{\sum_{i=1}^{n}\left(t_{ip} - t_{mi}\right)^2}{n-1}} \times \frac{1}{\underline{t_m}} \times 100$$

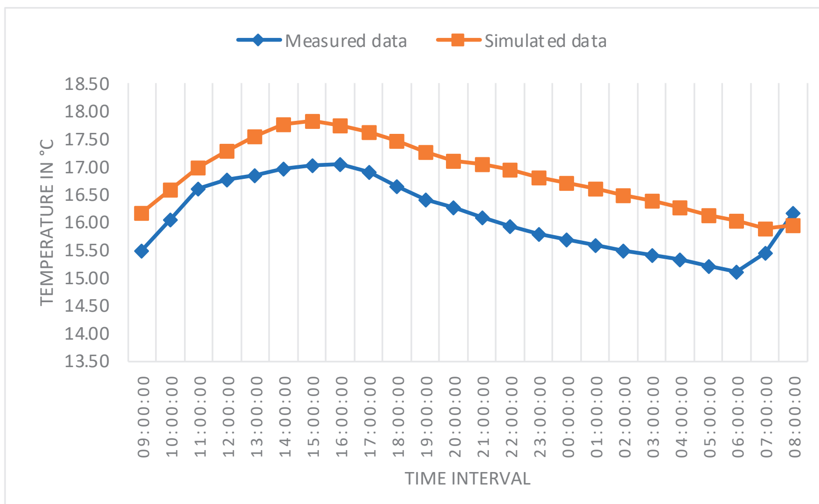


Figure 18. Temperature difference between monitored and simulated values in the main room.

In this study, the simulated temperature values (t_{ip}) of node i were compared to the monitored temperature values (t_{mi}) of node i, where the arithmetic means of a sample of n measured temperature data (t_m) were calculated, and n was the number of monitored temperature data during the monitoring period. The normalized mean bias error (NMBE) indicator provided information on the difference between the simulated and measured temperatures. A positive NMBE value indicated that the simulated temperatures were higher than the monitored data, whereas a negative value indicated that the simulated temperatures were lower than the monitored temperatures. The ideal NMBE value was zero.

The coefficient of variation of the root mean square error (CV(RMSE)) indicator quantifies the relative correlation, expressed as a percentage, between the differences (simulated temperatures minus monitored temperatures) and the average of all the monitored temperatures [24,26]. The CV(RMSE) value is always positive, and an ideal value would be zero, indicating optimal accuracy. NMBE values, on the other hand, indicate the presence of systematic error or bias in the simulation. In contrast, CV(RMSE) serves as an indicator of precision, reflecting how closely the simulated results align with the monitored data. The temperature differences between the monitored and simulated temperatures in the main room are presented in Table 5. Additionally, the coefficient of variation of the root mean square error (CV(RMSE)) was calculated, which was 4.46%, and the normalized mean bias error (NMBE) was found to be 4.28%. Both values were below the maximum validation threshold of 25% recommended by the ASHRAE [28].

Table 5. Temperature differences between monitored and simulated data in the main room. NMBE and CV (RMSE) values.

Time	Measured Data	Simulated Data	NMBE (%)	CV (RMSE) (%)
09:00:00	15.49	16,17	4.28	4.46
10:00:00	16.06	16.59		
11:00:00	16.61	16.99		
12:00:00	16.77	17.28		
13:00:00	16.84	17.56		
14:00:00	16.97	17.76		
15:00:00	17.02	17.83		
16:00:00	17.05	17.75		
17:00:00	16.91	17.63		
18:00:00	16.66	17.46		
19:00:00	16.42	17.27		
20:00:00	16.26	17.10		
21:00:00	16.10	17.05		
22:00:00	15.93	16.95		
23:00:00	15.80	16.82		
00:00:00	15.69	16.71		
01:00:00	15.60	16.60		
02:00:00	15.50	16.49		
03:00:00	15.42	16.39		
04:00:00	15.33	16.28		
05:00:00	15.21	16.13		
06:00:00	15.11	16.03		
07:00:00	15.45	15.89		
08:00:00	16.16	15.94		

3.3. Assessment of Annual Thermal Performance

A comprehensive one-year simulation of the building was conducted using the validated model and its corresponding input parameters for annual simulations. In order to examine the dynamic free-running thermal behavior of the living room environment, the impact of free gains was deliberately disregarded.

Figure 19 presents the annual differences in the temperature of the simulated main living room and the outside temperature. It can be observed that the outdoor temperatures are representative of cities located at altitudes between 2000 and 3000 m above sea level in the Andean Mountain region on the Equatorial Line (such as the city of Azogues), which have a cold climate that affects the indoor temperatures of buildings. Regarding the indoor thermal comfort range between 18 °C and 22 °C, it can be observed that the simulated temperatures are mostly below the range. The number of hours per year that the building is below 18 °C is 7.338 h, that below 16 °C is 6.207 h, and that below 10 °C is 538 h. These values show that the indoor environment of the building, despite having temperatures below the comfort range, never reaches extreme cold temperatures or below 0 °C, which is a characteristic of buildings that do not have active heating systems. This has caused the residents to adapt to lower temperatures and compensate for them with clothing [20].

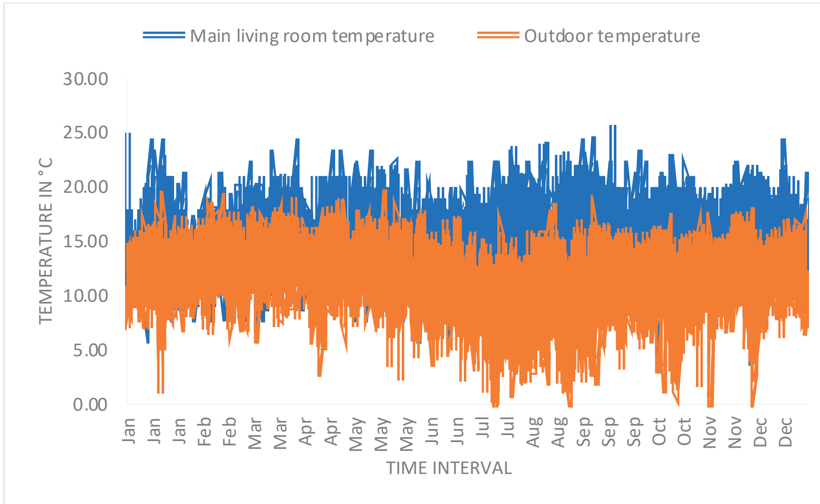


Figure 19. Variations in air temperature of the main room over one year.

Figure 20 presents data on the relative humidity throughout one year at an hourly resolution. The humidity ratio in the main living room ranged from 4 to 11.7 g of water vapor per kilogram of dry air. The upper limit of relative humidity was set at 70%, indicating that the relative humidity values did not exceed this threshold throughout the evaluation period.

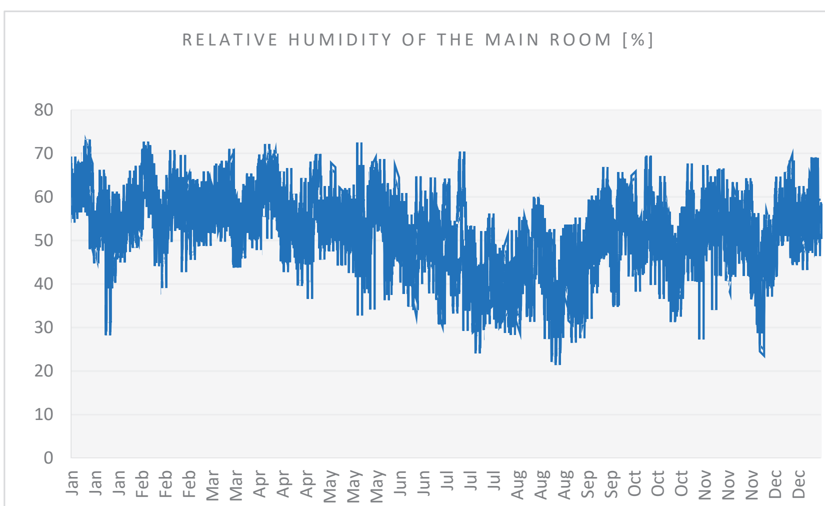


Figure 20. Variations in relative humidity of the main room over one year.

In Figure 19, the dashed line of simulated temperatures for one year in the living room shows the range obtained, with indoor temperatures ranging from 15 °C to 18 °C and relative humidity between 2 and 9 g of water vapor per kg of dry air, with an acceptable upper limit of 19 g of water vapor per kg of dry air and maximum acceptable relative humidity of 70%. This indicates that the traditional courtyard houses in the city of Azogues adapt well to the local climatic conditions, primarily due to their thermal masses. Additionally, the higher simulated temperatures in the living room compared to the exterior, even at night, demonstrate that the case study has passive design strategies that improve the indoor temperatures. This temperature value could potentially improve if the U-value of the thermal transmittance of the building's envelope decreases to 2.35, as stipulated by local regulations. In this way, the internal thermal gains would be retained, and more appropriate thermal comfort standards could be achieved.

If we analyze the annual thermal performance of the building with the temperature and relative humidity data from the living room, we can verify that the simulated temperature in the main room exceeds the 16 °C recorded during the monitoring period. Additionally, the annual relative humidity of the simulated main room matches the relative humidity recorded in the same space at 70%, allowing the building's occupants to adapt to the indoor environment despite having slightly lower temperatures than those recognized as the comfort range.

4. Conclusions

The traditional vernacular architecture of Azogues represents a rich source of knowledge and ancestral wisdom that contributes to sustainable development. However, studies on vernacular architecture remain limited.

The qualitative analysis conducted on the dwelling in the present study reveals that the strategies employed in the passive design of existing vernacular houses in Azogues are effective in coping with the local climatic conditions. This response is primarily supported by the thermal insulation of the building envelope, the buffering space (central courtyard), and the shape and orientation of the house in relation to the prevailing wind direction.

The placement of the main spaces that enclose the building around the central courtyard, as well as the surrounding corridors, also contributes to generating shade for the interior spaces located on the ground floor and to protecting the indoor thermal environment from solar radiation.

The passive features also contribute to improving the thermal insulation of the building, such as the use of locally sustainable materials in the construction of the building envelope, which is composed of bahareque. The relationship between the filled openings and the central courtyard allows natural light to enter the interior spaces, enhancing the thermal comfort of the dwelling. The in situ measurements conducted in the building align closely with the findings derived from the qualitative analysis. The experimental monitoring revealed that the traditional house benefits from natural ventilation. However, to avoid high air velocities within the spaces, it is advisable to avoid simultaneously opening a door and window in the direction of the prevailing external wind.

The experimental stages of monitoring and in situ measurements, followed by validation through dynamic simulation in EnergyPlus/Open Studio, were crucial for the studied building typology, which involved a higher degree of uncertainty and complexity. Only through this approach was it possible to quantify the thermal behavior of the building. However, there were limitations in the monitoring time for indoor environmental parameters, and it is recommended to extend the monitoring period for as long as possible to obtain more comprehensive data.

This study concludes that the climate-responsive strategies of traditional houses inspired by vernacular architecture, primarily based on natural ventilation, solar protection, thermal buffering, and heavy thermal mass, are effective in providing improved thermal comfort on hot days and cold nights.

The optimal use of local resources, a good location and geographic orientation, and an optimal building layout, along with a reasonable interior environment and the design of window openings can contribute to improving the thermal comfort of a building, even without the consumption of fossil fuels. Based on these findings, it is important to suggest that the passive design strategies used in traditional houses be employed, as much as possible, by new generations of architects and construction engineers in modern buildings located in climatic zones similar to those of the city of Azogues.

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Article

The Rise and Evolution of Wind Tower Designs in Egypt and the Middle East

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Abstract: Throughout history, vernacular architecture has sought to provide inhabitants with comfort, using local materials and techniques while drawing inspiration from the local culture. This goal has helped natural and passive environmental building techniques to emerge, evolve, and develop. Even though we are increasingly dependent on mechanical ventilation and cooling solutions, passive techniques are in favor due to global climate challenges and the drive toward sustainable construction. One of the most well-known passive cooling techniques is the windcatcher, or wind tower, as it is known in the Middle East (also known as a *malqaf* in Egypt). Windcatchers, which appeared in Egypt during the Pharaonic era, were also present in other vernacular Middle Eastern countries such as Iran and Iraq, and they differed in design and materials. This research aims to extract, analyze, and compare windcatchers throughout historical eras in Egypt and other Middle Eastern countries across three main eras: ancient, medieval, and modern. This study thus provides a timeline for developing these passive cooling systems, demonstrating how they were integrated into architecture over millennia. This study also investigates the design differences in these vernacular models, including their shapes, number of sides, and orientation, and correlates them to climatic and architectural conditions. The results highlight that the vernacular wind towers corresponded to the prevailing wind directions and the ventilation needs of the connected spaces. Furthermore, the findings question the effectiveness and appropriateness of some of the modern incorporations of wind towers, which borrow their design from local precedents.

Keywords: wind towers; passive cooling; natural ventilation; Egypt; Middle East; historic analysis

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1. Introduction

Over the years, human comfort has been a key priority in the process of designing spaces. Before mechanical solutions were available, attempts to achieve this goal were naturally passive. Today, however, even with advancements in mechanical solutions, passive methods remain in favor due to the increasing need for sustainable solutions because of current global environmental concerns. Historically common passive solutions include shading devices, ventilation techniques, and passive cooling and heating techniques. One of the most prevalent cooling and ventilation techniques is the wind tower, also known as a windcatcher. Wind towers are also known as *malqafs* in Egypt, one of the very first countries to implement this feature. Wind towers have become increasingly interesting for researchers due to their potential to create passive cooling and reach target human comfort levels indoors. Wind towers have been in use since the Ancient Egyptian era, primarily used in buildings to facilitate ventilation and indoor cooling. Additionally, windcatchers were used widely during the Egyptian Medieval era and were known as a *malqaf*, literally meaning "catcher".

However, there is a gap in the literature that studied windcatchers in Egypt throughout its history. Most researchers who studied windcatchers in Egypt focused on the medieval era, especially the Islamic, but none, to our knowledge, thoroughly studied all eras starting from Pharaonic to the modern era going through Coptic and Islamic. In addition, the same gap appeared with research studying windcatchers in the Middle East; it either focused on ancient or modern, but no studies, to our knowledge, went through all eras together. Another new aspect of this current research is analyzing the reason behind the windcatcher form and design, how it differed between regions, and why. Thus, the three primary eras including ancient, medieval, and modern are studied in this research to extract, analyze, and compare windcatchers from different historical periods in Egypt and other Middle Eastern regions. This will contribute to advancing the knowledge of vernacular wind tower designs and bring awareness to their potential as a passive design solution that contributes to sustainability and reduces energy consumption, especially in Egypt. This study offers a timeline for advancing these passive cooling systems, showing how they were incorporated into architecture over centuries. It presents and investigates case studies found in the three eras, explains their main aspects and design differences, including their shapes, number of sides, and orientation, and correlates them to climatic and architectural conditions. This research mainly utilizes the literature and archives to investigate the cases mentioned. Wind roses of each region investigated are then further studied to determine wind towers' correspondence to the prevailing wind directions and the ventilation needs of the connected spaces. The findings also call into question several contemporary windcatcher incorporations that borrow their design from local precedents in terms of efficiency and suitability.

The main purpose of a wind tower is to direct wind toward the desired indoor areas of a building and cool the directed air in the process [1]. Nejat et al. [2] explain, in their research on two-sided wind towers, that wind towers operate on two main forces: wind and buoyancy. The wind force is derived from the difference in wind pressure indoors and outdoors. This feeds into the ventilation function of the wind tower. Buoyancy can be generally understood as the force that pushes objects upward when placed in a fluid [3]. Because hotter air has a lower density than cooler air, it tends to 'float' or rise above the cooler air [4]. Therefore, the force of buoyancy feeds into the cooling function of wind towers [2]. This is because, in buoyancy-driven air shafts, the exhaust vents are placed on the top and connected to a chimney leading them outward, while the inlets are placed lower to allow the cool, dense air to be vented into the space [4]. When the correct number of inlets is provided (such as in multiple-sided wind towers), more wind can be driven into the wind tower to be processed in this way. The number of sides and inlets depends on the prevailing wind directions and wind speed. These operation processes are illustrated in Figure 1.

In short, buoyancy is a force that acts mainly on density [3,4]. This paper's Section 5 will discuss both in more detail.

To provide sufficient ventilation, wind towers are usually built to be tall structures erected on building rooftops [5], enabling them to catch the fast-traveling wind [5] away from the building level below, where the surrounding buildings may obstruct wind movement and slow it down. Moreover, wind towers are directed toward the prevailing wind direction or the direction from which the most significant wind movement occurs [6]. This ensures the highest movement of wind possible, especially on hot summer days when wind movement is typically low. Figure 2 shows a typical Egyptian *Malqaf*.

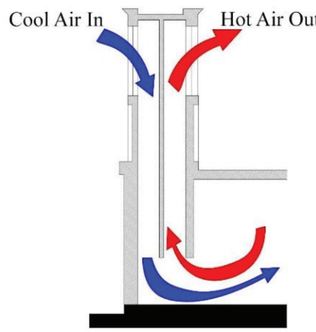


Figure 1. A section showing how windcatchers work (modified by the authors; adapted from [7]).

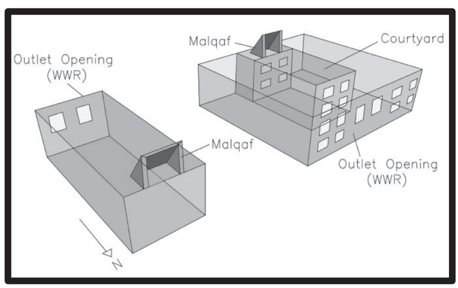
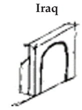


Figure 2. The main components of wind towers (modified by the authors; adapted from [8]).

Before the industrial revolution, people living in hot, dry zones deferred to natural cooling methods. Using easily obtainable materials, inhabitants of the Middle East tried alternative methods to ventilate their homes. Windcatchers were widespread in the Middle East, with significant variance in their construction and design. Despite the various structures, they all served the same purpose: to channel favorable prevailing winds into residential areas [9]. Table 1 below shows how different traditional wind tower designs started to appear in different regions [10].

Table 1. Traditional wind tower designs and information (modified by authors; adapted from [10]).

	Egypt 	**Iran** 	**Persian Gulf** 	**Iraq** 	**Pakistan** 	**Afghanistan** 
Climatic zone	Hot and dry	Hot and dry	Hot and humid	Hot and dry	Hot and humid	Dry and semi-hot
Prevailing wind direction	Northwest	Northeast	Breeze	Northwest	Southwest	North
Shape of cross-section	Rectangle	Square/rectangle/hexagon, octagon	Square	Rectangle	Square	Square
Average dimensions (m)	-	0.5 × 0.8 0.7 × 1.1	1 × 1	0.5 × 0.15 1.20 × 0.60	1 × 1	1 × 1
Height (m)	One story above roof	3–5	3–5	1.80–2.10	5 and above	1.5 from roof
Orientation to the prevailing wind direction	Ordinary	Diagonal	Diagonal	Ordinary	Diagonal	Ordinary
The ceiling of the wind tower	30° Slope	45° Slope	30° Slope	45° Slope	45° Slope	30° Slope
Ventilated area	Dining plus one room	Dining room and basement	Dining plus others	Only the basement	All rooms	All rooms
Air flow	One side	Multi-side	Multi-side	One/two sides	One side	One side
Evaporative cooling	Sometimes	Sometimes	Never	Sometimes	Never	Never

In Section 2, this paper starts by reviewing case studies from Egypt showing examples of wind towers from the Pharaonic, Medieval, and Modern eras. In Section 3, this paper presents case studies from the Middle East, which studied historical and modern towers. In Section 4, this paper compares and contrasts the case studies and examines their characteristics vis-à-vis wind rose of the different locations in which they appear. This analysis reveals that the attributes (e.g., number of sides, height, roof shapes, etc.) of historical wind towers have been highly influenced by the weather and wind characteristics of the location, with the modern towers deviating from this trend. This paper then ends with a discussion and conclusions highlighting the key findings, the main limitations of this study, and the areas requiring further investigation and research.

2. Case Studies from Egypt (Ancient and Modern)

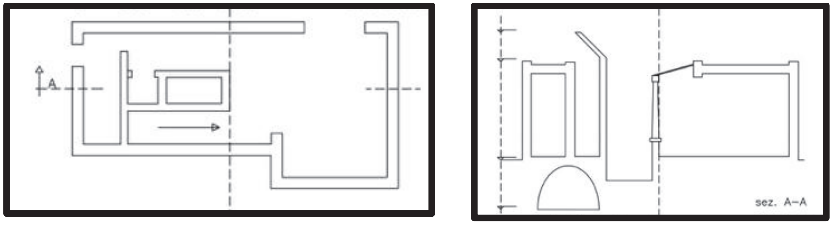
2.1. The Pharaonic Era

Windcatchers have been depicted in Ancient Egyptian paintings, indicating that the concept of the windcatcher traces back to the early Pharaonic era [11]. For example, the Pharaonic house of Neb-Amun was portrayed in a painting on his tomb dating back to the Nineteenth Dynasty (1336–1294 BC). It displays a windcatcher with two openings, one facing windward to receive cool air and the other facing leeward to expel hot air by suction [11,12], as seen in Figure 3a. Furthermore, a papyrus (Figure 3b) from the *Book of the Dead* (1543–1292 BC) references windcatchers' existence during the Pharaonic era. The elevation at the right end of the drawing shows two similarly aligned triangles, which are presumably windcatchers [13].

(**a**) (**b**)

Figure 3. (**a**) Windcatchers of the Pharaonic house of Neb-Amun, recreated by authors based on [14], (**b**) *Book of the Dead* showing a building with a wind tower at the lower right corner shown in the red square (about 1336–1294 BC) (modified by the authors, based on [13]).

A papyrus displaying the floor plan of a house constructed in the second century BC was one of the papyri found "in a former dump near Oxyrhynchus in Egypt" (modern el-Bahnasa) (Figure 4). By "extracting their volumes from the redrawing of the plan and the average height typical of the interiors' volume, the speed was 1.5–2 m/s, assuming that the chilly air inside was descending at that rate. This indicates that it takes about 4–5 s to completely refill the air. It is important to note that the presence of an atrium significantly increases internal comfort and improves efficiency [13].



(**a**) (**b**)

Figure 4. (**a**) Ground plan and (**b**) section of a house found on a papyrus that dates back to the second century BC and is currently located in the Museum of Art and Archeology, Oxford (modified by the authors; adapted from [13]).

2.2. Medieval and Ottoman Eras

Windcatchers were prominent in Cairo during the Fatimid and Mamluk eras, from the 10th century to the 19th century. However, according to King, the origins of Medieval Cairo's windcatchers are unknown. They could have been introduced during the time of the new city's establishment in 969 AD or shortly afterward [12]. According to Hassan Fathy's book, *Architecture for the Poor* (1973), the old houses in Cairo relied on windcatchers for ventilation in the principal halls (*qa'as*) that caught the wind at a high elevation "where it is strong and clean". As shown in Figure 5, the hot air escaped through the high central part of the *durqa'a* (a small, covered court) [15].

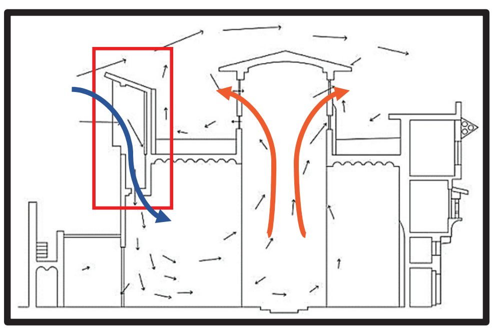


Figure 5. Arrows showing the air movement in Qã'a of Muhib Al Din Ash-Shãf'i Al-Muwaqqi with a red box highlighting the location of the wind catcher (modified by the authors; adapted from [16]).

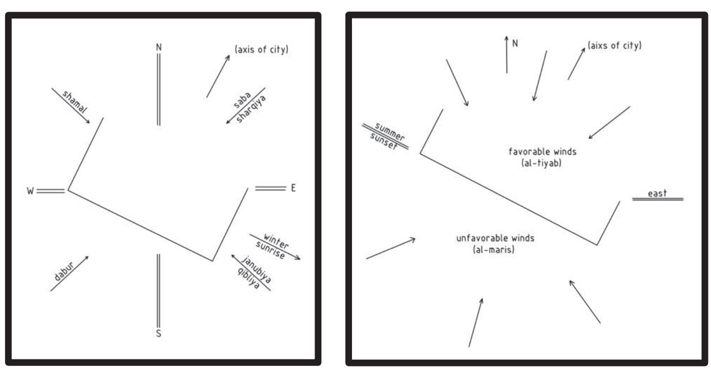
The primary typologies of buildings with windcatchers were mosques, *madrasas* (religious schools), and mausolea. However, relatively few windcatchers were observed after several were restored around 1900 AD [12]. According to David King [12], the medieval windcatcher in Cairo is the most overlooked historical Islamic architectural feature in the mainstream literature, but it was significantly used in Cairo (known then as Fustat) from the 10th to 19th centuries. During this time, most of the homes in Cairo were built with windcatchers on their roofs to drive the cool northern wind down to refresh the living quarters below [12]. Pages 125–128 of King's book show photographs dating back to the 19th century, depicting the presence of windcatchers all over the city [17].

The medieval windcatchers in Cairo were designed to capture the cool northern wind, as can be concluded from their unique shape. According to Williams (2008), a medieval windcatcher resembled the head of a stairway, the shape of which dates back to the Pharaonic era [18]. This distinguishing feature emerged beyond a flat roof, usually at a 30-degree angle. A simple medieval windcatcher consisted of a lightweight wooden rectangular awning that covered an opening in the ceiling of the room below. It was frequently connected with a vertical duct made of masonry or a light structure that directed the flow deep into the building's lowest floors. The opening into the room was either a horizontal opening through the ceiling or a vertical opening in one of the walls. The windcatcher successively supplied rooms on different levels, whereby the first openings of the column or duct were through vertical openings in the wall, and the last was opened through a horizontal opening in the ceiling [19,20]. Windcatchers could also be built into the windward façades of a building, which differ very little from simple windows [19].

Medieval writings do not mention the materials used to make Cairo windcatchers. The oldest surviving example of a medieval windcatcher (shown in Section 2.2.7, is on the roof of the Qã'a of Muhibb al-Din), which indicates that the windcatchers could have been made of stone, thereby enabling them to survive for centuries. However, according to 19th-century paintings, they were primarily made of wood or reed and were plastered on both sides and hence, had a short lifespan [10]. Nonetheless, there are still intact grilles on the ceilings of historical buildings, indicating that windcatchers were not only present but prevalent [12]. Furthermore, to filter dust from the air, windcatchers were protected with bay wood [21].

Moreover, Olivier Jaubert's observations [19] showed that using wooden shutters on the upper aperture at the roof level controlled airflow and the shutting of the windcatcher [12]. Jaubert further discussed systems for controlling and closing the windcatcher during the medieval period [19]. The devices could be a door leaf on an opening fitted in the wall, horizontal shutters placed on the opening in the ceiling or halfway up the duct, or windows and shutters made of wood and directly applied to the inlet of the windcatcher, which delimited the northern opening of the windcatcher [19].

The windcatchers ranged in size from small structures to immense structures taking up the entire top floor of the building on which they were installed (as seen in the House of Alfi Bey in Section 2.2.9 and Musāfirkhāne Palace illustrated in Section 2.2.10) [12]. According to Ibn Yunus, a medieval astronomer, the rectangular base of the windcatcher is suggested to have dimensions of 10:5 1/2. For example, the windcatcher on the Musāfirkhāne is approximately twice as wide as deep, as shown in Figure 6a. On the other hand, those recommended by Najm al-Dīn al-Miṣrī, another medieval astronomer, were approximately 4:1, as shown in Figure 6b [12]. The following sub-sections of this manuscript present several examples of Medieval Egyptian windcatchers in various building typologies.



(**a**) (**b**)

Figure 6. (**a**) Plan showing the range of wind directions in Egypt, according to the medieval 14th-century encyclopedist al-Qalqashandī, in relation to the orientation and shape of windcatchers defined by Ibn Yūnus four centuries earlier. (**b**) Plan showing the range of favorable wind directions in Egypt according to Najm al-Dīn al-Miṣrī (modified by the authors; adapted from [17]).

2.2.1. Christian Hermitages in the Desert of Esna (Upper Egypt), Fifth–Sixth Centuries

Hermitages consist of a courtyard and peripheral rooms dug into the desert ground. Previous surveys carried out on hermitages do not provide evidence for the use of windcatchers. However, ventilation methods were found in these hermitages. Ventilation ducts were arranged to establish the necessary cross ventilation since the entire hermitage was dug into the ground, and the rooms had only one façade in the courtyard on the opposite side of which there was a ventilation duct. The reserves usually had a ventilation chimney (Figure 7). Doors open into the courtyard and were exposed to the wind.

Similarly, horizontal ducts were sometimes circular and flared like a funnel open to the outside of the courtyard (Figure 8). Reliable archaeological traces confirm that this duct was equipped with a wooden shutter closing system. The direction of the wind determined the relative position of the different parts of the hermitage [19,22].

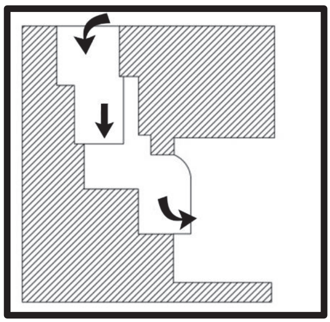


Figure 7. Illustrative sections of a reserve ventilation chimney, the arrows signify the air flow (modified by the authors; adapted from [22]).

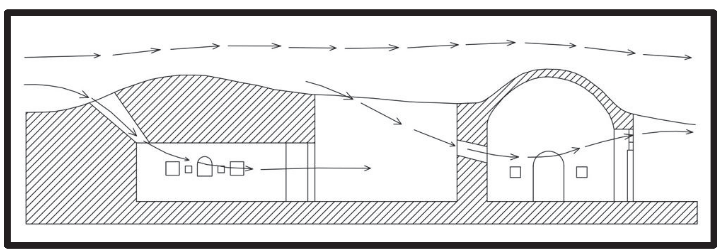


Figure 8. Airflow in a hermitage in the desert of Esna, which was built in the ground, the arrows signify the air flow (modified by the authors based on [22]).

2.2.2. Christian Hermitage (Building No. 45), the Kellia, Fifth–Seventh Centuries

The Kellia hermitage included a non-central courtyard and half-excavated rooms. The rooms were generally attached to the northwest corner and along the north wall on the long side, exposed to the prevailing wind. "Amphora necks" integrated into the masonry allowed air to circulate from one room to another. In the roof, two or more holes were present on the domes, depending on the room size. On the north side, the hole was surmounted by a small conch-shaped edicule designed to catch the wind, and on the leeward side, a simple or round opening allowed the air to escape (Figure 9) [19].

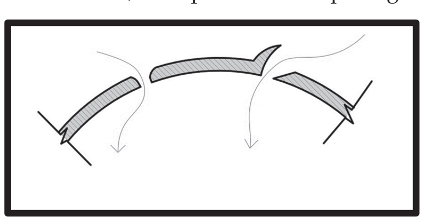


Figure 9. Christian hermitage (building no. 45), the Kellia, the arrows signify the air flow (modified by the authors; adapted from [19]).

2.2.3. Virgin Mary Hanging Church (Seventh Century)

Figure 10 shows two existing windcatchers in the Virgin Mary Hanging Church. The windcatchers are located above the *narthex* or lobby, facing northeast [23].

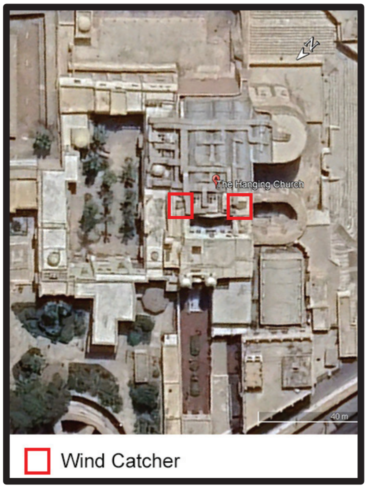


Figure 10. Virgin Mary Hanging Church, top view (taken from Google Earth based on [23]).

2.2.4. Virgin Mary Al-Damshareya Church (Eighth Century)

Windcatchers can be seen in Figure 11. They are located above the *narthex* or lobby, facing northwest and above the south chapel [23].

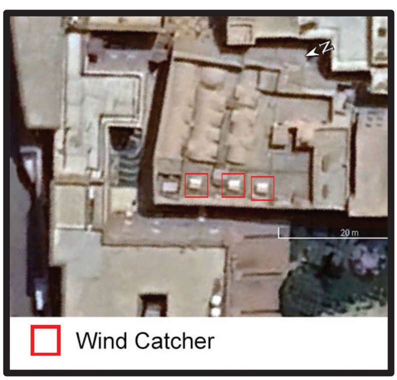


Figure 11. Virgin Mary Al-Damshareya Church, top view (taken from Google Earth based on [23]).

2.2.5. Mosque of Al-Ṣāliḥ Ṭalā'iʿ (1160 AD)

In the Mosque of Al-Ṣāliḥ Ṭalā'iʿ, immediately behind the Imam's pulpit is a rectangular opening 71 cm wide and 1.82 m high that is fitted with a grille. The opening opens into a rectangular 0.5 m^2 vertical shaft (Figure 12). The shaft ascends through the thickness of the wall until it reaches the roof to an awning facing north [18,19,24,25]. Similarly, the Madrasa of al-Nāṣir Muḥammad (1295–1304) has an opening to the right of the mihrab of the Madrasa and a vertical shaft embedded in the masonry of the wall, 1.72 m deep, which are what remains of the windcatcher installed in the main north-western *Iwan* [19,24].

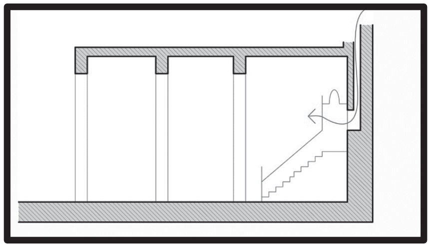


Figure 12. Section of the Mosque of al-Ṣāliḥ Ṭalā'iᶜ at the minbar and the duct leading to the windcatcher, the arrow signifies the air flow through the duct and into the space (modified by the authors; based on [19,25]).

2.2.6. The Khanqah of Sultan Baybars Al-Jashankir (1306–1310)

The *Khanqah* (hostel for Sufis) of Sultan Baybars al-Jashankir had seven windcatchers [12]: one at the back of the side alcoves of the main *Iwan* (a vaulted portal opening onto a courtyard), one in the frontal niche of the opposite *Iwan*, and two in each of the *maglis'* back walls. The windcatcher in the western *Iwan*, the top of which is still accessible, offers additional information. A duct extends relatively high in the brick masonry and contains wooden beams, which are the remains of a canopy. A cornice halfway up the duct supports a horizontal element, allowing the windcatcher to be closed. The mausoleum, which was added later, features an equally interesting ventilation system. Two vertical ducts are embedded in the thickness of the dividing wall between the khanqah's west *Iwan* and the mausoleum (Figure 13). They lead to the roof and the alcoves on either side of the mihrab, each with its own wooden door leaf. There is cross ventilation between the vestibule of the mausoleum, which has large windows looking to the street, and a skylight on the roof, in addition to the ducts [19].

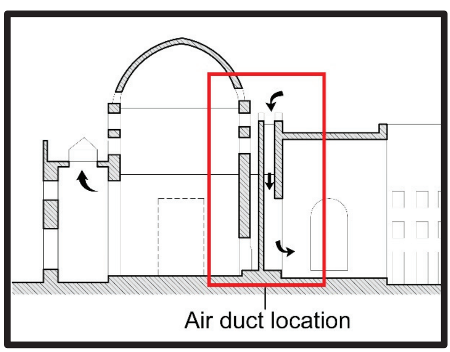


Figure 13. A longitudinal section of the Khanqah of Sultan Baybars al-Jashankir complex showing the ducts in the walls, the arrows signify the air flow through the space (modified by the authors based on [19]).

2.2.7. *Qã'a* of Muhibb Al-Din Ash-Shãf'i Al-Muwaqqi (1350)

To capture the ideal air volume and direct it downward, a windcatcher was installed in the northern Iwan [8] at *Qã'a* of Muhibb al-Din Ash-Shãf'i Al-Muwaqqi. The windcatcher on this building is the oldest example of a windcatcher made of stone that has survived for more than 500 years [12]. A model of the building (Figure 14), created by Hassan Fathy, shows the windcatcher on the left and the pavilion in the center [12,19]. The windcatcher's expansive canopy is open to the north and west but is closed to the south using a buttressed wall. The windcatcher was kept closed using wooden shutters. Moreover, through the windcatcher's opening in the ceiling, one can observe the amount of light that enters the space and illuminates the Iwan's front wall [19]. The air movement in the building is illustrated in Figure 5, which shows the windcatcher supplementing the building with cool air while the skylight extracts the hot air.

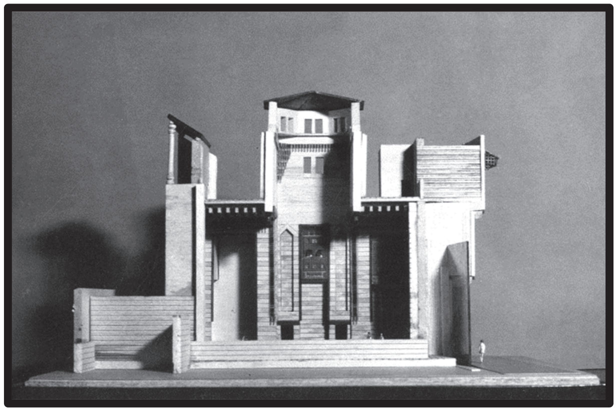


Figure 14. A 3D model of *Qa'a* of Muhibb al-Din al-Shāfi'i al-Muwaqqi. Reprinted with permission from [26]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo.

2.2.8. Suheimi House (1648)

The House of Suheimi includes a wooden windcatcher with a barred aperture toward the north (Figure 15). The roof of the windcatcher projects out in front of the aperture, and its form is typical of elaborate 19th-century architecture. In front of the windcatcher, a skylight topped with a small wooden dome on top of the *qa'a*'s entrance was designed to facilitate air circulation toward the *qa'a* [19]. The western side of the windcatcher should have been open as well or would have been before restorations [12]. This house had at least five *malqafs*, some on the second floor and in ruins, and a sixth one at the *qa'a* [12].

Figure 15. An interior view of the windcatcher of Bayt al-Suhaymi.

2.2.9. House of Alfi Bey (18th Century)

The courtyard at the House of Alfi Bey is dominated by three large windcatchers (Figure 16). The one on the left appears to be closed on the western side, whereas the eastern side of the one on the right is open. This contradicts the recommendations of medieval writings regarding a proper windcatcher opening [17].

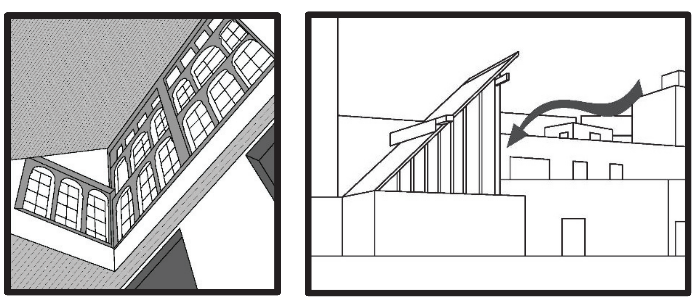
Figure 16. The exterior garden of the house of Alfi Bey is dominated by a decorative large windcatcher, 1821 [27]. This material is free to use, according to the Library of Congress in (see https://www.loc.gov/item/2021669727/ (accessed on 1 June 2023).)

2.2.10. Musāfirkhāne Palace (1779–1788)

The imposing windcatcher on the roof of Musāfirkhāne Palace survived until 1998. Its west side was open, as described in medieval astronomical sources [12]. The windcatcher was placed above the second floor on the antechamber preceding the *qa'a*. Moreover, the northern opening was protected using a rectangular roof projection [19], and the west side was open, thus agreeing with the medieval standards of windcatchers [12].

2.2.11. House of Al-Sinnārī (1794)

At the House of Al-Sinnārī, a large wooden canopy facing north constitutes the roof of the small *Iwan* south of the main *qa'a* (Figure 17). The northern and western openings are provided with frames with glazed windows. The *qa'a* has an unusual layout with the artificial separation established between this southern *Iwan* and the *durqa'a* using a high grille with a *Mashrabiya* (decorative projective windows prominent in Islamic architecture). This grille allows air to circulate from the windcatcher, through the *Iwan*, toward the dome on an openwork drum of the *durqa'a*. Dominated by the *malqaf*, this small *Iwan* appears as an independent room, which also acts as an antechamber [19].

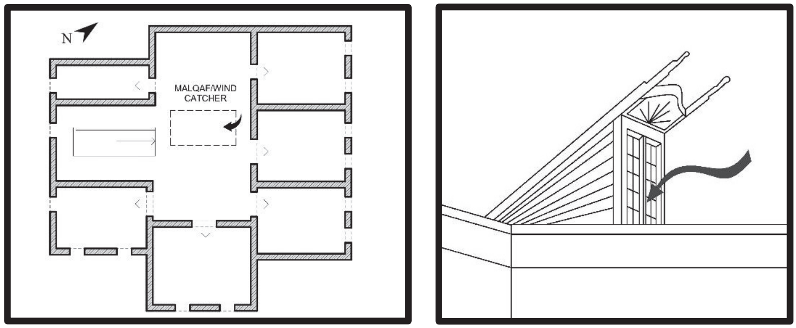


(**a**) (**b**)

Figure 17. (**a**) An inside view of the windcatcher in the House of Al-Sinnārī. (**b**) An outside view of the windcatcher, the arrow signifies the air flow to the windcatcher (modified by the authors; based on [17]).

2.2.12. The Palace of Al-Jawhara in the Citadel (1814–1829)

All that seems to be left of Muhammad Ali's Palace's ventilation system is the single windcatcher shown in Figure 18 [12]. The awning of the windcatcher is on the ceiling of the central room, which connects to the peripheral rooms as well as the access staircase and the two sanitary and service blocks [19].



(**a**) (**b**)

Figure 18. (**a**) Plan for the Palace of al-Jawhara showing the location of the windcatcher (modified by the authors based on; [19]). (**b**) The northeastern elevation of the windcatcher, the arrows signify the air flow to the windcatcher (modified by the authors based on [19]).

2.3. Modern Era in Egypt: Hassan Fathy's Designs, AUC Towers, and Sixth of October Villas

Hassan Fathy and Ramsis Wissa Wassef were the most broadly known pioneer architects who revived vernacular architecture that used domes, vaults, and windcatchers. Hassan Fathy used the windcatchers in residential and public buildings such as the primary school for girls in El Gourna Village, where all the classes have an adjacent windcatcher facing north, from which the wind flows in and exits from another opening above the room. Placed inside the windcatcher of El Gourna is a sloped metal tray filled with wetted charcoal over which the air flows to cool the building. This object is similar to the *salsabil* that was used in the *Iwans* and halls of old Arab homes. Consequently, the windcatcher used in Gourna reduced the classroom's temperature by 10 degrees [15].

2.3.1. Hamdy Seif Al-Nasr House (1945)

Another building designed by Hassan Fathy that incorporated the use of windcatchers, more specifically, wooden ones, which is called Hamdy Seif Al-Nasr House, 1945 [28]. The windcatcher on the left of the dome directed airflow past a *salsabil* (cooling plate) that was kept damp using a continuous trickle from the earthenware water pot held above it (Figures 19 and 20) [16]. Since then, a roof stairway was added to the air shaft, changing its original design [28].

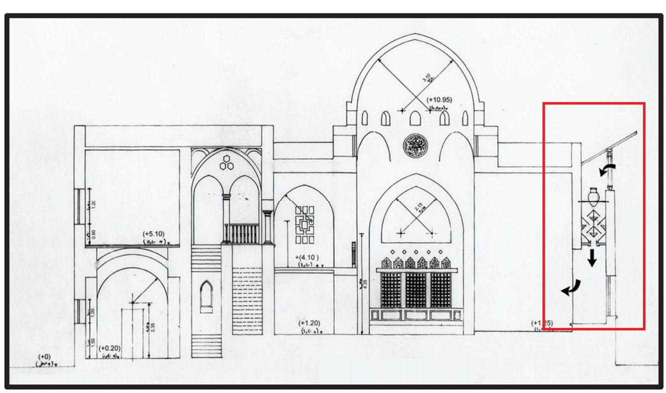
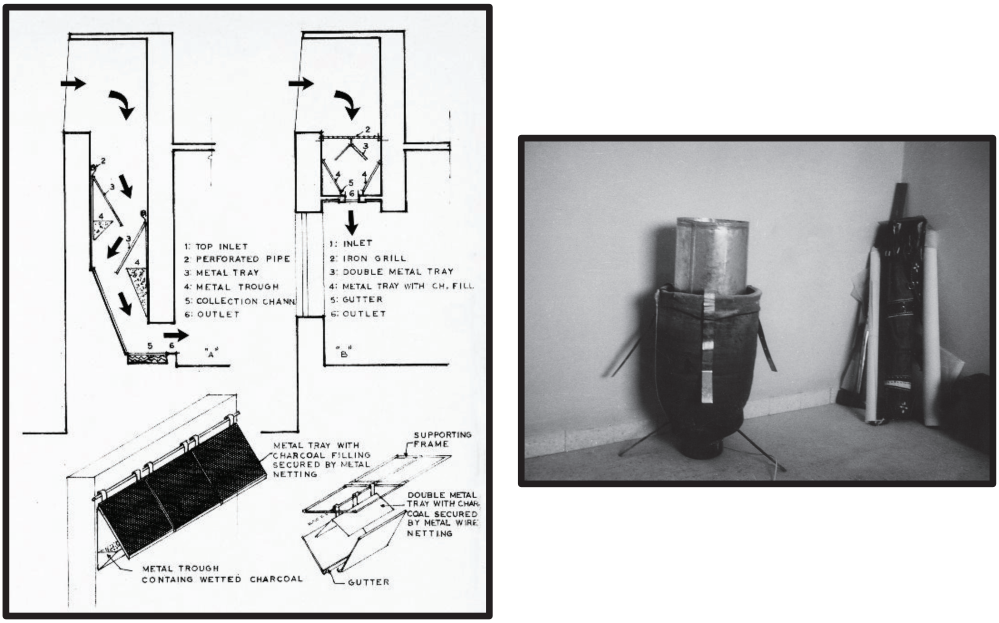


Figure 19. Section of Hamdy Seif Al-Nasr House, 1940s, the arrows signify the air flow from the wind catcher and into the space it ventilates and red boxes indicate the location of the wind catchers. Reprinted with permission from [29]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo.



(**a**) (**b**)

Figure 20. (**a**) Sections 'A' and 'B' show the cooling mechanism used in the windcatcher of Hamdy Seif Al-Nasr House, the arrows signify the airflow. Reprinted with permission from [30]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo. (**b**) The earthenware water pot is used to drip water and provide evaporative cooling in the windcatcher used by Hassan Fathy. Reprinted with permission from [31]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo.

2.3.2. The Market of New Baris in El Wady El Gedid (1967)

Hassan Fathy also used a windcatcher in the market of the New Baris Oasis, where the windcatcher directs the wind to flow in the basement where all biodegradable fresh produce is stored for the sake of preservation [16]. The planning, sectioning, and elevation of the market of New Baris in El Wady El Gedid ensure that wind is drawn inside using a row of windcatchers. The wind is then directed into the basement, where the goods susceptible to spoiling are stored (Figures 21 and 22).

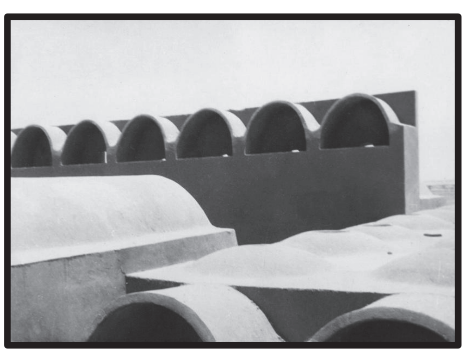


Figure 21. The market of New Baris in El Wady El Gedid, 1960s. Reprinted with permission from [32]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo.

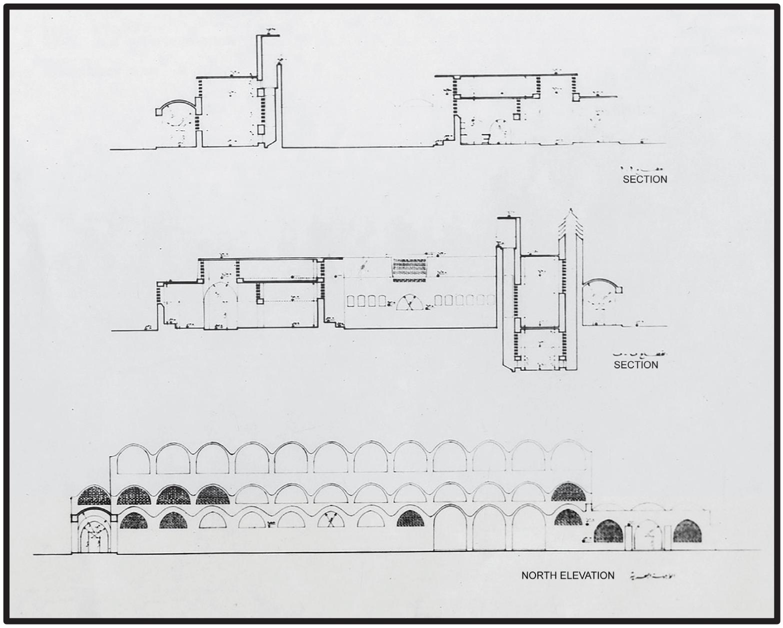
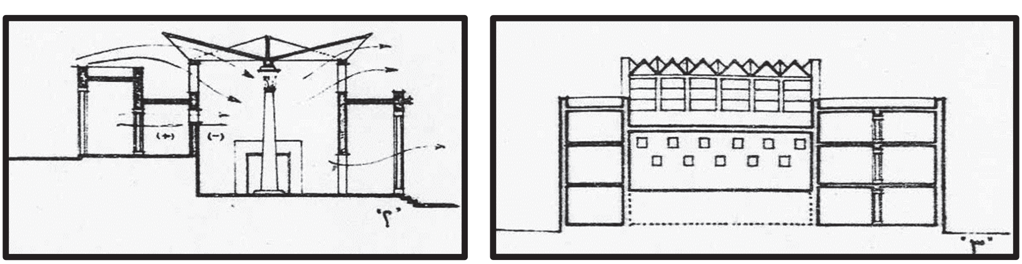


Figure 22. Sections and elevation of the market of New Baris in El Wady El Gedid, 1960s. Reprinted with permission from [33]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo.

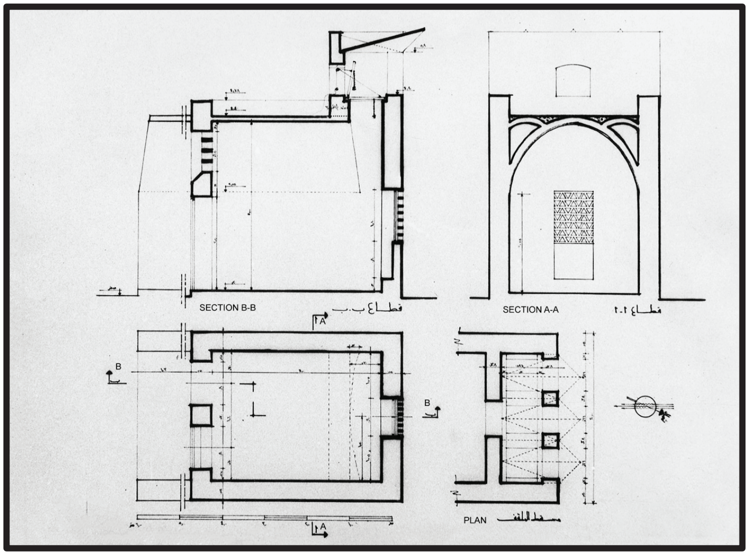
2.3.3. The Luxor Cultural Center (1970)

The Luxor Cultural Center was a complex designed by Hassan Fathy in 1970 for the Egyptian Ministry of Culture. The center was planned to be in the Middle of Luxor, close to the Sidi al-Wahsh Fatimid Mosque. However, only the main hall was finished. Moreover, the architect's plans for natural ventilation were disregarded. The entire interior space was to be cooled using a large windcatcher [34]. As seen in the sections in Figure 23, Fathy's design of the windcatcher was open on opposite sides: one opening was the inlet, which faced northeast, and one was the outlet that let the hot air escape, facing southwest. This iteration of the windcatcher seems to have been an experimental approach for the *malqaf* by Hassan Fathy, as seen in the Experimental Rooms for the Ministry of Scientific Research designed by the architect (Figure 24). Unfortunately, the envisioned windcatcher was closed off, making the roof form meaningless [35].

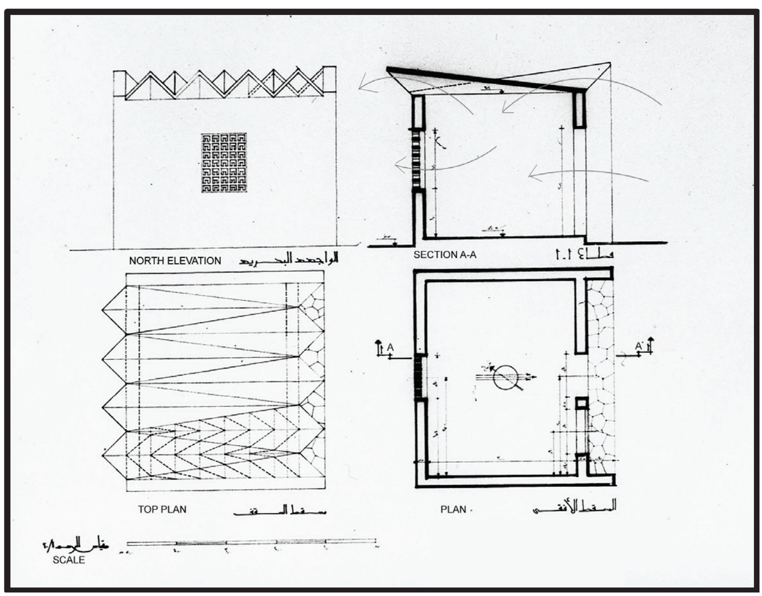


(**a**) (**b**)

Figure 23. (**a**,**b**) Sections of Luxor Cultural Center by Hassan Fathy, 1960s, the arrows signify the air flow. Reprinted with permission from [35]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo.



(**a**)

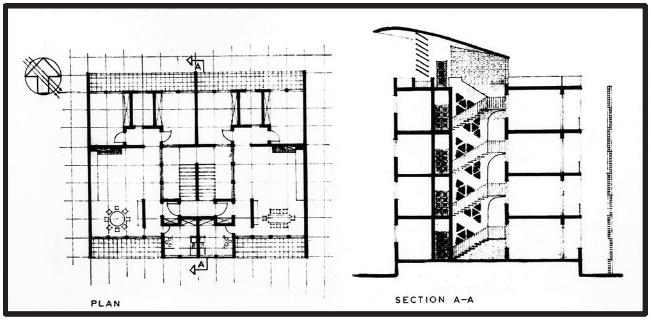


(b)

Figure 24. (**a**,**b**) Sections and plans for the Experimental Rooms for the Ministry of Scientific Research by Hassan Fathy, the arrows signify the air flow from the wind catcher and into the space it ventilates. Reprinted with permission from [36]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo.

2.3.4. A Modern Apartment Building

The design for a modern apartment building by Hassan Fathy shows the use of a staircase as a *malqaf* with a cooling mechanism based on evaporation on top of the stairwell. From the plan and section in Figure 25, the windcatcher is shown to be facing south, which is different from the typical orientation of the windcatcher in Egypt.



(**a**) (**b**)

Figure 25. (**a**,**b**) Plan and section 'A-A' for a modern apartment building by Hassan Fathy. Reprinted with permission from [37]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo.

2.3.5. Villa "A" in 6th of October City

Architect Ramy El Dahan was one of Hassan Fathy's students. Continuing his mentor's legacy, he designed many public and residential buildings using elements of vernacular architecture. Among the buildings he designed is "Villa A" (See Figures 26 and 27) in El Thawra El Khadra, located next to El Sheikh Zayed on the 6th of October City. It was designed using a courtyard, vaults, and domes, and he used the windcatcher to provide cool natural ventilation for the whole villa. The windcatcher, located on the villa's ground floor, connects to the basement. This allows the air to circulate and drop more of its temperature. As seen in Figure 27, some of the air shafts are also embedded in the walls. The main function is to pull the air that has been circulating underground to cool down the basement (see Figure 26) to the ground and upper two floors. These shafts achieve this cooling using small openings in the walls of the rooms. Overall, this process helps cool down the air in most indoor spaces, and the villa's ability to operate successfully without mechanical air conditioning units is evidence of this method's success [38].

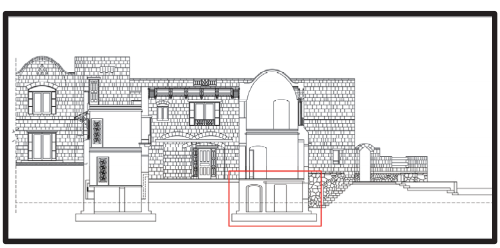
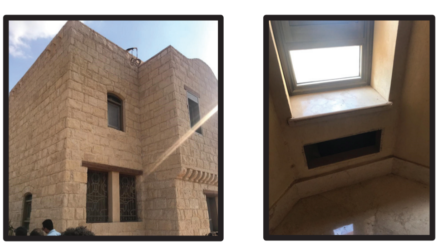


Figure 26. Villa A section showing the basement, in the red square, where the wind from the wind catcher is directed and cooled down.

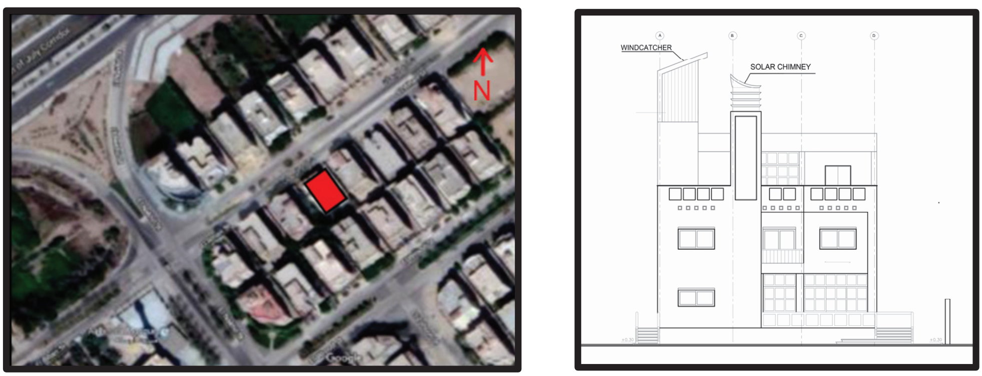


(**a**) (**b**)

Figure 27. (**a**) Windcatcher, and (**b**) air shaft.

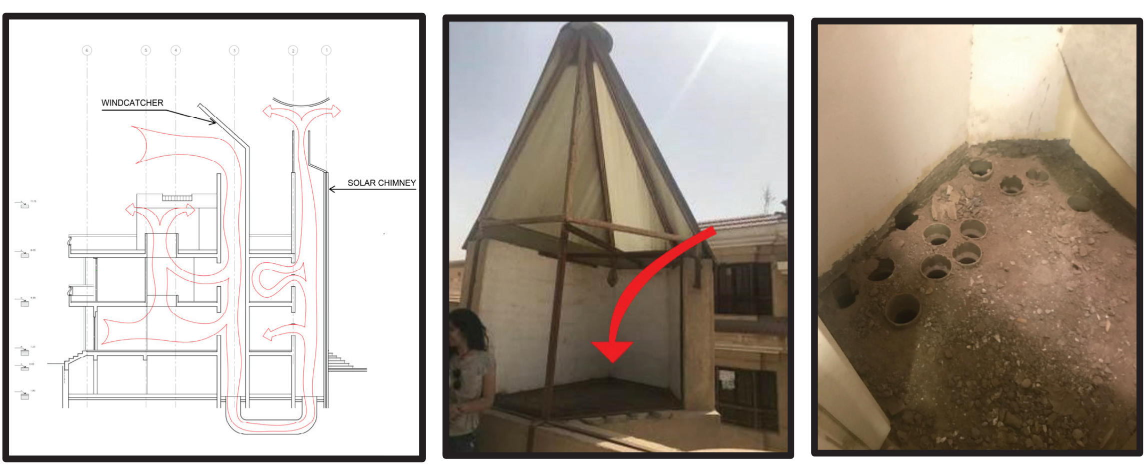
2.3.6. Villa "B" in 6th of October City

Another successful modern example of a residential building that uses a windcatcher is a villa designed by Prof. Dr. Ahmed Reda Abdeen located in 6th of October City (Figure 28a). This villa also utilizes passive design techniques for cooling. The villa consists of three floors in addition to the basement. The windcatcher that is studied in this villa rises above the roof by 1.5 m and is oriented north-westward (Figure 28b). It works alongside a solar chimney, which is painted black to further enhance the natural ventilation in the villa's indoor spaces (Figure 29). Both features are connected using underground tubes, as can be seen in Figure 29c. Because the solar chimney is painted black, the air flowing inside it is at a higher temperature due to the color's high absorption of heat. This forced increase in temperature causes the unwanted hot air to be vented upward faster. This hot air is then replaced with cooler air coming from the windcatcher. As in Villa A, this windcatcher also pulls the outdoor air into the underground tubes where it circulates to cool down, and then it is led upward to be provided inside the rooms. This process successfully cools the rooms in the villa without the need for mechanical cooling [38].



(**a**) (**b**)

Figure 28. (**a**) Villa B layout (in red) (modified by authors, adapted from [38]). (**b**) Villa B elevation.



(**a**) (**b**) (**c**)

Figure 29. (**a**) Section showing the windcatcher and solar chimney. (**b**) View of the wind catcher (modified by authors, adapted from [38]). (**c**) View of the underground tubes in the windcatcher.

2.3.7. The American University in Cairo New Campus (2008):

Finally, the AUC campus master planned by CDC Abdel Halim and Sasaki and Associates, specifically, the School of Sciences and Engineering (SSE), which was designed by Sasaki and Associates, offers two full-scale prototypes of windcatchers [39]. Both towers face the same direction, as shown in Figure 30, and are located over semi-enclosed atria that open on courtyards and have a similar configuration, where both are four-sided square plans with interior cross partitions. However, they differ in size (height and side length) and interior and exterior finishes. Moreover, Tower A is a straight-tower chimney with fixed metal louvers (Figure 31a), while Tower B features an inclined tower with operational louvers (Figure 31b). Both towers provide natural ventilation to the connected spaces, which decreases the use of mechanical cooling.

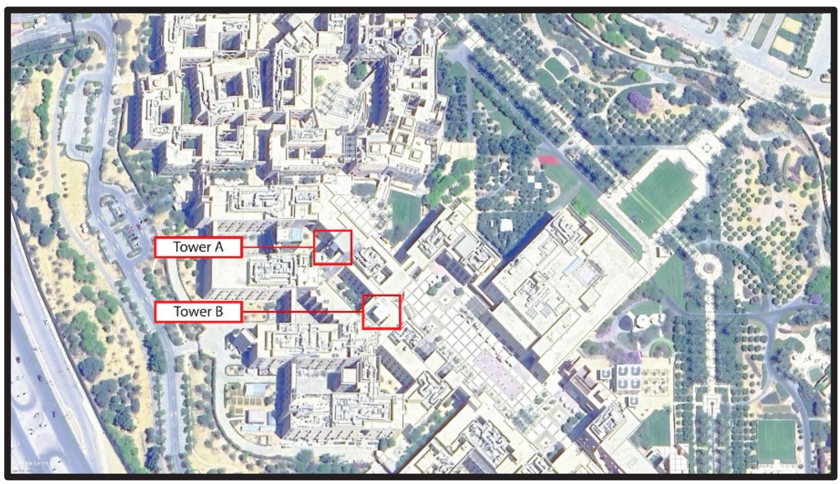


Figure 30. Site plan for the SSE building at AUC (obtained from Google Earth and adapted by the authors).

(**a**) (**b**)

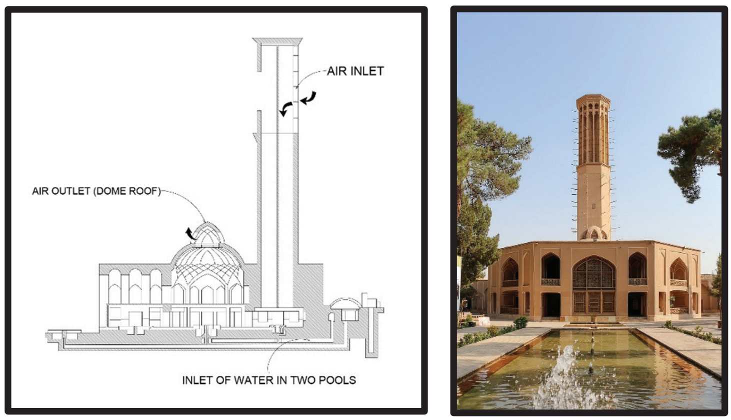
Figure 31. (**a**) Tower A is a straight-tower chimney with fixed metal louvers and (**b**) Tower B is an inclined tower with functional louvers.

3. Case studies from the Middle East (Old and New)

3.1. Historical Case Studies from the Middle East

3.1.1. The Tower of Dolatabad Windcatcher, Iran

Acknowledged as a world heritage site by UNESCO, the Dolatabad Garden in Yazd is home to Iran's tallest wind turbine with a 34 m height, which was rebuilt after it collapsed in the 1960s. The eight-sided wind tower is used to ventilate the building by sucking the air that flows inside the building and passing it over a small rocky pool through the water jet. It is then is channeled to other rooms, as seen in Figure 32 [40].

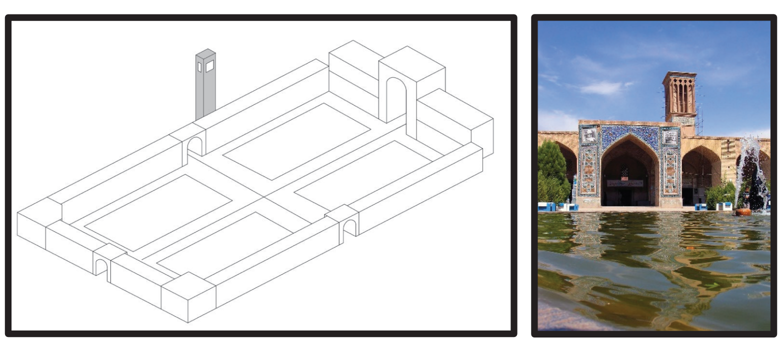


(**a**) (**b**)

Figure 32. (**a**) A section through the building and windcatcher (modified by the authors; adapted from [40]). (**b**) Photograph showing the tower by Bernard Gagnon under a GNU Free Documentation License.

3.1.2. The Ganjali-Khan Square Windcatcher, Iran (1596–1621)

The Ganjali-Khan complex in Iran consists of a wide rectangular square with 50 × 100 m dimensions (Figure 33). This square comprises important public and semi-public buildings such as a caravanserai on the eastern side, a mosque on the northeastern side, a bathhouse to the south, a water reservoir and school to the west, and a mint to the north. The windcatcher, the tallest element in the square, is located near the north entrance and is a four-sided square shape decorated with brick and tilework. It is attached to the single-floor arch lobby connected to the courtyard (Figure 33b) [41].



(**a**) (**b**)

Figure 33. (**a**) A 3D isometric drawing showing the placement of the windcatcher in the Ganjali-Khan Square (recreated by the authors; based on [41]). (**b**) Photograph showing the tower by Cyrus the Great under a Creative Commons Attribution 2.5 Generic license.

3.1.3. Bastakiya Windcatchers, Dubai, UAE (1890)

The Bastakiya windcatchers were built by Persian immigrants who migrated from Iran to Bastak in Dubai [20,42]. The immigrants started to construct structures like those in Iran, where the climate is warm and humid. Furthermore, windcatchers in Bastakiya, Dubai, are four-sided and usually square in a plan of approximately 2.5 × 2.5 m^2 [20]. Figure 34 shows photographs of the four-sided Dubai windcatchers. Moreover, Figure 35 shows the possible air movement in a windcatcher in Dubai as analyzed by Hassan Fathy [43].

Figure 34. Four-Sided windcatchers in Bastaqyia, Dubai, UAE. modified by authors, original photograph by Russavia under Creative Commons Attribution 2.0 Generic.

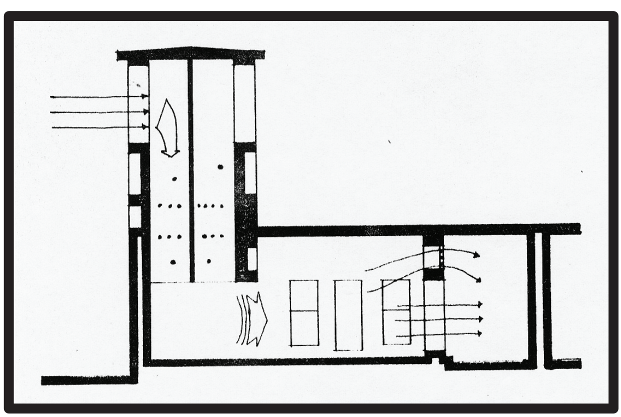
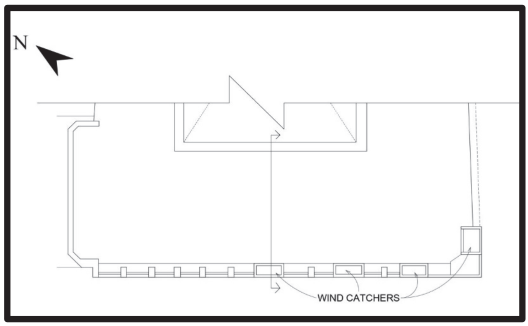
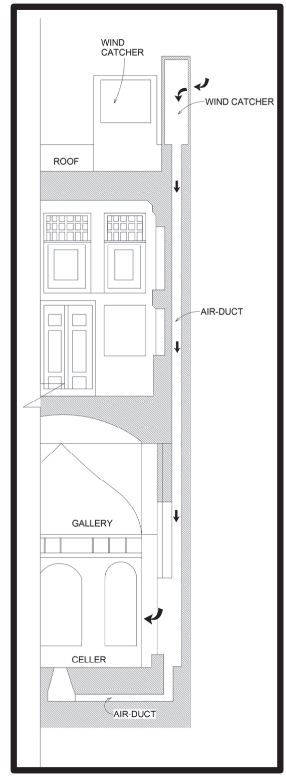


Figure 35. Air movement in a wind tower in Dubai that was designed by Hassan Fathy in the 1970s. Reprinted with permission from [43]. 2023. Courtesy of the Rare Books and Special Collections Library, The American University in Cairo.

3.1.4. Diwan-Khanat Al-Asterabadi, Baghdad, Iraq (19th Century)

Iraqi architect Dr. Subhi Al-Azzawi documented the windcatchers in the Diwan-Khanat al-Asterabadi, Baghdad, Iraq, where there are four windcatchers. Three face the northeastern wind, and a larger one faces northwest (Figure 36a). Furthermore, the scoops of the windcatchers face inwards to the building rather than outwards. The unidirectional windcatcher (Figure 36b) reaches through the floors of the building and as far as the basement. Moreover, to aid in cooling the wind, a sizeable baked clay jug (*zir*) of water is placed at the base of the column [12].





(**a**) (**b**)

Figure 36. (**a**) Plan and (**b**) section showing four windcatchers in Diwan-Khanat al-Asterabadi, Iraq (modified by the authors; adapted from [17]).

Moreover, windcatchers in Iraq are usually rectangular in cross-section. The column of a typical windcatcher in Iraq varies from 15 to 60 cm in width, and its height never exceeds the roof of its building but may begin from the roof. The roof of a windcatcher is inclined at 45°. A windcatcher is usually 2 m from the roof. Columns usually end in the basement of the building, where the air flows through small metal windows underground [44].

3.2. Modern Cases from the Middle East

3.2.1. Masdar City, Abu Dhabi, UAE (2010)

Despite the fact that Masdar City is located in an area with moderate wind, the city's planners decided to place the wind tower in the Public Square at the Institute of Science and Technology in Masdar City, rather than in a home or other enclosed space, to have a greater impact on more populated areas. At the base of the wind tower is a sizable urban plaza that is home to a variety of purposes, including cafes and other retail establishments, as well as a seating area that enjoys beautiful weather. The thermal performance of the enormous windcatcher in the public metropolitan area, which depends on modern technology, is shown in Figure 37. A stage is elevated beneath the windcatcher and is used for performance. Sensors manage the automatic louvers on the windcatcher. These sensors keep track of the predominant wind direction and control the louvers to send the wind down the tower in the appropriate direction. As an evaporative cooling system, the tower also has a high-temperature mist jet to humidify the incoming air and make it cooler at ground level [45].

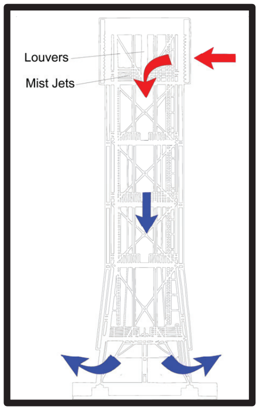


Figure 37. A section through the windcatcher that shows its performance, the red arrow signifies hot air, while the blue shows that the air has been cooled (modified by the authors; adapted from [45]).

3.2.2. Khalifa Stadium, Doha, Qatar (2017)

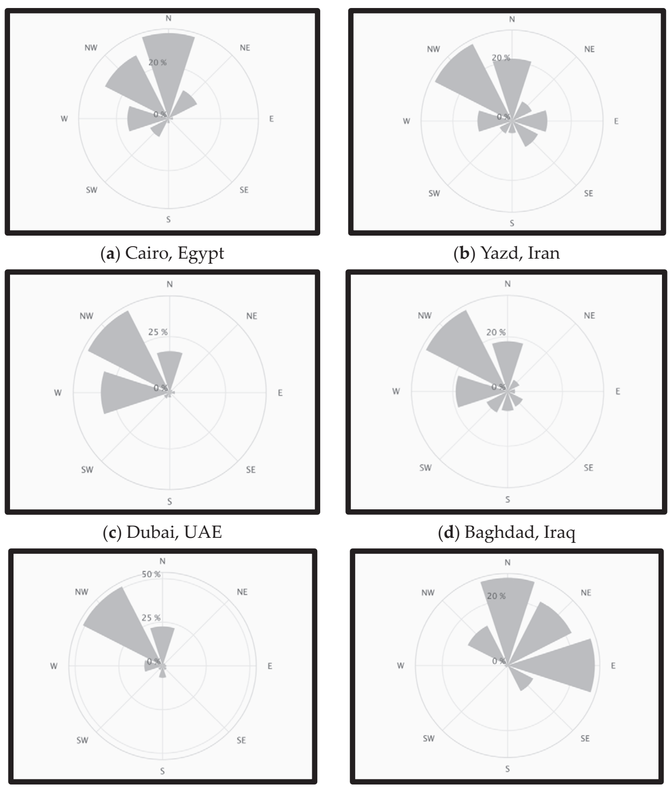
Another example of a building using windcatchers as a cooling tool is the Khalifa Stadium, which was built for the FIFA 2022 World Cup in Qatar (Figure 38). The cooling system used by the fans is installed in cooling towers located more than 1 km away from the stadium. The cooled water is pumped from the towers into the stadium. There are 9 units in the NCR2610 fan, with a 26 ft diameter, and 10 blades with an airflow capacity of 433.4 m^3/s [46].

Figure 38. Khalifa International Stadium showing the wind tower in the red square; adapted from [47].

The Khalifa International Stadium is the largest cooled outdoor stadium in the world. A system that works to reduce energy consumption was therefore used in this building. This system, called "urban refrigeration, "successfully keeps the players and the audience within the comfort range. In this system, refrigeration technology is 40% more sustainable than conventional techniques. This is made possible with the utilization of an energy center located one kilometer from the stadium. In this center, the cooled water is carried through a pipe to the venue. The cold water then arrives, cools the air, and then is pushed toward the center of the stadium, the playing field, and the seating areas to reach a total of about 500 vents dispersed around the stands. Moreover, because the cold air is denser, it remains low near the ground; therefore, not all the hot air enters [46]. This is accomplished by the effect of buoyancy force, as discussed in the Introduction section of the paper.

4. Results of the Case Study Analysis

The tables below contain a summary of the cases investigated in this study. Windcatchers started showing up during the Pharaonic and Coptic eras, but the shape, the number of sides, orientation, and openings seem to have been developed further during the Islamic era, when there was more understanding of wind movement and direction prevalence (see Figure 6) [12,17]. Table 2 shows that 85% of the windcatchers in Egypt are either single-sided or two-sided, and most are oriented toward northern and western directions. This study consisted of 12 case studies from the Pharaonic to the Coptic to the Islamic eras. Overall, 50% of the cases of windcatchers studied from the aforementioned eras are single-sided. Moreover, 33.3% of them are two-sided, all of which have their openings adjacent to each other, and all of which are from the Islamic era. In total, 75% of the two-sided windcatchers face north and west, which is the span of the prevalent wind directions in Egypt (see wind rose in Figure 39a). Furthermore, there are cases for which the type and orientation of the wind towers are unknown since they no longer exist [10].



(**a**) Cairo, Egypt (**b**) Yazd, Iran

(**c**) Dubai, UAE (**d**) Baghdad, Iraq

(**e**) Abu Dhabi, UAE (**f**) Doha, Qatar

Figure 39. Wind roses in the regions studied. (Note: wind roses are available at the website: World-Weather Weather Archive in Yazd Available online: https://world-weather.info/archive/ accessed on 16 April 2023/).

The table further explains how windcatchers changed from the Medieval to the Modern era. Overall, 37.5% of the modern case studies have windcatchers that follow the design standards of vernacular windcatchers. Nonetheless, it seems that Hassan Fathy developed the *malqaf*, as seen in the cases of the Luxor Cultural Center and Experimental

Rooms for the Ministry of Scientific Research, where the openings of the windcatchers face opposite directions. A study examining various windcatcher design parameters as a means for the passive cooling of low-rise buildings in Egypt during the summer shows that an iteration similar to Hassan Fathy's resulted in the highest air change per hour [48]. For example, none of the ancient or medieval windcatchers are flat-roof, and 37.5% of the modern windcatcher case studies have flat roofs. The effectiveness of modern flat roof windcatchers is yet to be studied in Egypt's climatic conditions.

Table 3, on the other hand, indicates that wind towers throughout the Middle East varied in type, ranging from single-sided to cylindrical types. It is worth noting that both modern wind towers studied are cylindrical. The shapes found in the tables below align with the findings in Table 1 [9].

The following wind roses in the various studied regions determine if the windcatchers studied here considered the prevalence of the wind. Cairo's wind rose shows that the prevailing wind comes primarily from the north and northwest. More than 32% of the wind appears from the north, followed by more than 27% from the northwest. No wind whatsoever comes from the span between the south and east, and negligible amounts of wind are received from the remaining directions (Figure 39a). This explains why wind towers in Cairo are typically single-sided or two-sided. It would be useless, and maybe even harmful to the speed of the wind coming in, to have many unnecessary openings in the tower's design when only one general direction is receiving most of the wind.

Like Cairo, Yazd's wind rose shows that most of the wind comes from the northwest and north. More than 29% of Yazd's wind appears to come from the northwest. This is followed by slightly more than 21% from the north. On all other sides, very little wind is received (between 4 and 11 percent) (Figure 39b). This explains why wind tower designs in Iran vary in their number of sides, as all sides receive wind, even if very little, as seen in the examples above for the tower of Dolatabad and the Ganjali-Khan Square windcatchers. Therefore, the designs depend on each area's specific prevailing wind directions.

In Dubai, the wind rose indicates that the wind comes primarily from the northwest and west. Slightly more than 40% of the wind in Dubai comes from the northwest. This is followed by more than 30% coming from the west. Almost no wind at all comes from the span between the southwest and northeast (only between 0.9 and 2.1 percent) (Figure 39c). Even though there seems to be a prevalent wind direction (northwest) in Dubai, the windcatchers found in Bastaqyia, Dubai, UAE are four-sided, which might seem contradictory to the typical use of one-sided windcatchers for places that have a prevalent wind direction.

The prevailing wind in Iraq is generally from the northwest, comprising 33.4%, followed by the west and the north follow, with each receiving approximately 18% of the wind. Based on the information on the wind rose shown in Figure 39d, single-sided windcatchers, just like in Egypt, are understandably used in Iraq, as the above example of Diwan-Khanat al-Asterabadi shows. However, the direction of the particular windcatcher that faces northeast does not align with the wind rose.

It is evident from Abu Dhabi's wind rose that the prevailing wind direction is northwest. It receives notable 51.1% of all the wind in Abu Dhabi. This is followed by less than half that amount received in the north (only 22.6%). All the other sides receive very trivial amounts of wind (between 1.8 and 10 percent) (Figure 39e). This can explain why the wind tower designs in this region vary, along with the previous wind rose from the Emirates. There is a high level of variance in the wind statistics from one region to the next; therefore, the design also varies in response to the wind statistics.

Lastly, Doha's wind rose indicates several diverse prevailing wind directions. This is because the differences between them are minimal. Doha receives 26.9% of its wind from the north, 26.7% from the east, and 22% from the northeast. The northwest direction receives slightly less, at almost 14%, and the southeast direction is slightly lower, at almost 9%. The rest of the sides receive negligible amounts of wind (<1%) (Figure 39f). This explains why there is diversity in the wind towers, which typically have many sides.

Table 2. Types of windcatchers throughout different eras in Egypt.

	Building	Type of Building	Historic Era	Type of Tower					Orientation of Openings	Shape
				Single Sided	Two-Sided		Four-Sided	Unknown		
					Opposite	Adjacent				
1	Neb-Amun	Residential	Pharaonic	√					Unk	Sloped roof
2	Virgin Mary Hanging church	Religious	Coptic	√					NE	Sloped roof
3	Virgin Mary Al-Damshareya church	Religious	Coptic	√					Unk	Sloped roof
4	Mosque of al-Ṣāliḥ Ṭalā'iʿ	Religious	Islamic	√					N	Unk
5	Madrasa of al-Nāṣir Muḥammad	Educational	Islamic					√	Unk	Unk
6	Khanqah and Mausoleum of Sultan Baybars al-Jashankir	Complex	Islamic					√	Unk	Unk
7	Qā'a of Muhibb al-Din Ash-Shāf'I Al-Muwaqqi	Residential	Islamic			√			N and W	Sloped roof
8	Suheimi House	Residential	Islamic	√					N	Sloped roof
9	Three windcatchers on the House of Alfi Bey	Residential	Islamic			√			N and E	Sloped roof
10	Musāfirkhāne Palace	Residential	Islamic			√			N and W	Sloped roof
11	House of Al-Sinnari	Residential	Islamic			√			N and W	Sloped roof
12	The Palace of al-Jawhara in the Citadel	Residential	Islamic	√					N	Sloped roof
13	Seif Al-Nasr House	Residential	Modern			√			Ukn	Sloped roof
14	New Baris Oasis Market	Commercial	Modern	√					N	Flat roof
15	Luxor Cultural Center	Complex	Modern		√				NE and SW	Sloped roof
16	Experimental Rooms by Hassan Fathy	-	Modern		√				NW and SE	Sloped roof
17	Modern Apartment Building	Residential	Modern	√					S	Sloped roof
18	Villa A in 6th of October City	Residential	Modern	√					NW	Flat roof
19	Villa B in 6th of October City	Residential	Modern	√					NW	Sloped roof
20	School of Sciences and Engineering (AUC)	Educational	Modern				√		NW, NE, SW, ad SE	Flat roof

√ = Yes

Table 3. Types of windcatchers throughout different eras in Middle East.

	Building	Type of Building	Historic Era	Country	Type of Tower				Orientation of Openings	Shape
					Single Sided	Four-Sided	Eight Sided	Cylindrical		
1	Tower of Dolat Abad		Islamic	Iran			√		All	Flat roof
2	Ganjali-Khan Square		Islamic	Iran		√			N, E, S, andW	Flat roof
3	Bastaqyia	Residential	19th century	United Arab Emirates		√			-	Flat roof
4	Four windcatchers on Diwan-Khanat al-Asterabadi	Residential	19th century	Iraq	√				Three face NE, and one faces NW	Flat roof
5	Institute of Science and Technology at Masdar City	Educational	Modern	United Arab Emirates				√	All	Flat roof
6	Khalifa stadium	Sports	Modern	Qatar				√	All	Flat roof

√ = Yes

5. Discussion and Conclusions

Although building height differences and homogeneity in the urban area are important factors for urban ventilation performance in an area [49], as studied in old cities such as Elazığ, this study did not address this point since urban morphology surrounding the case studies has changed throughout history. Therefore, this study relied on a wind rose analysis for each region.

In conclusion, the wind roses in the regions studied in this paper explain why the wind towers were designed the way they were. Some regions, such as Cairo, Dubai, Baghdad, and Abu Dhabi, receive wind in mostly one primary direction. Therefore, a one-sided or two-sided windcatcher is the prevalent choice in Cairo. Using two-sided windcatchers that are open on both the north and the west sides is especially beneficial because it supplies the building with the wind in the direction that ranges from north to northwest to west, which are the three most prevalent wind directions in Cairo. These results highlight that the vernacular windcatchers in Egypt and the Middle East correspond to the prevailing wind directions and the ventilation needs of the connected spaces. However, in Dubai, the use of four-sided windcatchers contradicts Dubai's wind rose, which shows a limited range in wind direction (even more limited than that of Cairo's). This could be because the Dubai windcatchers were built by Persian immigrants who were probably used to constructing four-sided windcatchers in Iran. Other types with more sides are better in regions with variable wind directions, such as Yazd, Iran [50].

Another aspect guiding the windcatcher design is its relationship to other spaces.

In Egypt, most of the windcatchers open directly into an enclosed space, whereas in other regions of the Middle East, windcatchers are used differently, where most of them are attached to open spaces or courtyards. This may also explain why windcatchers in Egypt are mostly unidirectional since they ventilate one specific space. In other regions, even if there is one direction for prevailing wind, we found multi-directional windcatchers, which ventilate a larger attached open space.

In Egypt, many modern windcatchers followed the design standards of medieval windcatchers. This can be evidence of the success of this design, albeit simple. On the other hand, Hassan Fathy tried to develop the vernacular windcatcher to have its openings face opposite directions. A study shows that an iteration similar to that resulted in the highest air change per hour [50]. Furthermore, the tables above show that 37.5% of the case studies on modern windcatchers have flat roofs. Further studies should be performed to measure the effectiveness of modern flat roof windcatchers in the climate of Egypt.

In the gulf, where the wind is scarce and the climate is harsh, new technologies are added to the wind tower to cool outdoor spaces rather than indoor spaces, such as in the cases of Masdar City in the UAE and Khalifa Stadium in Qatar.

A limitation of this study is that most of the windcatchers from the Pharaonic to the Medieval eras did not survive in Egypt since they were mainly made of wood or reed [12]. However, the cases of both the Madrasa of al-Nāṣir Muḥammad and The Khanqah of Sultan Baybars al-Jashankir, which do not have surviving windcatchers [12,19,24,26] prove their prevalent use during the Medieval era. There is evidence of the use of windcatchers in cases such as those in the presence of wind ducts. An extension for this research may include using extensive field and numerical studies, which could provide more insight into the design of historical windcatchers, thus advancing the research on sustainable vernacular elements such as the windcatcher. Additionally, combining a windcatcher analysis with current research on the effect of urban configurations on airflow and ventilation [49] could help provide new information on how to utilize these elements to improve ventilation in existing and new neighborhoods.

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Glossary

Diwan-Khanqah(s)	a reception hall plus hostel in medieval Islamic buildings
Durqa'a(s)	small, covered court in medieval Islamic buildings
Imam(s)	the person who leads prayers in a mosque
Iwan(s)	a vaulted portal opening into a courtyard
Khanqah(s)	a hostel for Sufis in medieval Islamic buildings
Madrasa(s)	a school in medieval Islamic buildings
Mashrabiya(s)	a type of projecting window in medieval Islamic buildings with carved wood latticework
Malqaf(s)	name used for wind towers in Egypt
Maglis(es)	a siting room for gatherings in medieval Islamic buildings
Mihrab(s)	a niche in the wall that points towards the direction of Mecca in a mosque, used to point the congregation during prayers
Salsabil(s)	a water fountain in medieval Islamic buildings
Qa'a(s)	a hall in medieval Islamic buildings
Zir(s)	a pot made of pottery for storing cool water in old houses

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Commercial Culture as a Key Impetus in Shaping and Transforming Urban Structure: Case Study of Hangzhou, China

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Abstract: Although the forces or impetuses that influence an urban structure are diverse, as has been fully studied by scholars from diverse research fields, some have played key roles. We endeavor to explore the key forces and mechanisms forming and transforming the urban spatial structure through Hangzhou, a multi-identity city. Upon studying classical ancient texts, historical maps, critical and recent literature, and POI data, we argue that the first and foremost driver of Hangzhou is commercial culture, rather than any other factors. Under a diachronic view and with graphic analysis, we distinguished Hangzhou's three major transformations during the last 900 years. Each transformation was, respectively, driven by the complicated commercial culture, which was mixed up with other elementary cultures, such as civil, leisure, landscape, and industrial. Furthermore, urban heritages were formed, inherited, revitalized, and reutilized during the transformation processes, which, in turn, enriched the commercial culture and vividly reshaped Hangzhou's urban structure.

Keywords: urban space; Lin'an; commercial force; leisure; urban heritage

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1. Introduction

Hangzhou, an ancient Chinese city with more than 2000 years' history, initially became known to the Western world in the thirteenth century due to the record of the Venetian traveler Marco Polo [1]. However, as one destination on the Silk Road, Arabic merchants and travelers had already visited the city even earlier [2], during Hangzhou's highlight moment, when it was the dynastic capital of an oriental empire, the Southern Song Dynasty (1127 CE–1279 CE). Japanese scholars took the lead in studying China's Tang (618–907 CE) and Song (960–1279 CE) cities, as they wrote the first urban history studies of these cities in the 1930s and 1940s, which triggered the interest of urban historians from other countries and internationally,; an interest that has persisted to this day [3].

Scholars' major interests in China's ancient capital cities such as Hangzhou are due to aspects, such as the social and economic development [4,5], urban planning [6], urban form or layout [7–10], spatial structure [11,12], functional areas [13], and comparative studies with other countries' capitals [14,15], among others. Some attention has also been paid to the analysis of urban form, spatial structure [16–18], urban heritage [19,20], and the evolutionary mechanism of modern local Chinese cities since the late Qing era, or from the nineteenth century on, and in contemporary China. Hangzhou is among these local cities, as its status as the country's capital was revoked following the Southern Song Dynasty, but it still functions as a critical local administrative and commercial center.

While Hangzhou's urban form, like those of most of the other ancient Chinese capital cities, is considered to have remained stable over a long period [21], its inner structure and patterns have changed greatly. Scholars from research fields, such as history, urban study, urban history, and planning history, have inspected Hangzhou's general history, with particular concern paid to Hangzhou's urban changes and the underlying mechanism of those changes. They attributed Hangzhou's urban structuring and restructuring factors to the complicated political, economic, social, cultural, religious, and even natural or landscape factors, as well as the interactions between those factors [1,4,22–25].

Specifically, quite a few studies have focused on the political or institutional factor being the main driver in shaping Hangzhou during the Southern Song Dynasty and contemporarily. Hangzhou became the dynastic capital in 1137 CE and was the largest city in the country when China's 'medieval urban revolution' [4] took place, in which Hangzhou played a key role. Many studies have acknowledged the existence and timing of this revolution, considering the institutional changes [4], structural changes [3], and dramatic transformations or transitions [1] of Chinese cities that took place during Tang to Song China, or from the ninth to the twelfth century. The political aspect is still critical, as Zhu [26] also studied Hangzhou's urban restructuring from the early 2000s, or since the post-reform stage, considering China cities' broad shift from industrialism to urbanism as related to political legitimacy. Three years later, he focused on Hangzhou's recent changes to a post-socialist city, considering the aspects of historical legacies, expanded urban range, and land use restructuring, among others [27].

Some studies attributed this institutional change or transformation and the correlated urban restructuring primarily to economic reasons. Southall, for example, studied the Southern Song Hangzhou or Hangchow region, paying particular attention to the reasons that the capitalist and industrial revolution failed to take hold in the Southern Song, though its elite was just as capable, innovative, and rational as those in eighteenth century England, who generated the industrial revolution [22]. Wang [28] retraced Hangzhou in the Ming (1368–1644 CE) and Qing Dynasty (1636–1912 CE), namely China's late imperial period, through the reorganization of its urban space, and acknowledged it as a nexus of commerce, administration, and popular culture. Some current works studied Hangzhou within the context of China's economic reform. Wei and Fang [29], for example, examined the rapid growth of Hangzhou's urban space and regarded China's reforms and globalization as the vital factors underlying its urban growth and restructuring.

Some other studies emphasized the evolution and function of the natural and cultural landscapes of the city, particularly the West Lake, in forming ancient Hangzhou as an icon of Chinese landscape appreciation [25] and modern Hangzhou as a scenic city [24,30]. In addition to the water landscape, exemplified by the West Lake, some attention has also been paid to the mountain landscape, exemplified by Wushan [31–33], in constituting Hangzhou's urban landscape. As these types of Shan-shui, or water–mountain landscapes, have rich cultural connotations, cultural [25] and religious [33] perspectives are also considered when tracing the ways in which Hangzhou's urban structure evolved throughout history.

Obviously, the drivers of a city's development are complicated and comprehensive, and these have been reviewed. Moreover, scholars attribute different drivers to Hangzhou's urban restructuring during different historic periods. However, Hangzhou is a multi-identity Chinese city, namely an ancient dynastic capital and modern local administrative center, and has been the largest oriental city for roughly 900 years. It is also a new oriental city of leisure and can hardly be studied through either a political or economic lens. Is there a primary impetus in the process shaping Hangzhou's urban structure throughout time? By what mechanism does this impetus shape and reshape Hangzhou's urban structure, if such an impetus exists?

To answer the first question, we assume, through studying the ancient texts, historical maps, and related literature, that the first and foremost driver of Hangzhou's sustainable development and urban structure transformation is commercial culture, rather than other factors. Commercial development force and correlated commercial culture once made Hangzhou the primary prosperity metropolis of some ancient empires and are still shaping contemporary Hangzhou. This force also generates and reuses the city's abundant legacies and heritages. As a result, Hangzhou presently occupies three World Heritages, namely the Archaeological Ruins of Liangzhu City, the West Lake, and the Grand Canal of Hangzhou section, which were, respectively, formed in different historical periods and have been sustainably retained. While the active roles of the West Lake and the Grand Canal of Hangzhou Section in shaping the city are widely recognized and studied, that of the Archaeological Ruins of Liangzhu City, Hangzhou's newly added World Heritage, in reframing the spatial structure of Hangzhou remains to be studied. Most current studies on Liangzhu are concentrated on its own rise and fall [34], its interaction between the environment and climate change [35], and its Neolithic culture [36], among others.

In addition, we find, through a literature review, that the literature concerning Hangzhou's urban transformation is made up of either historic or contemporary studies. In other words, Hangzhou's urban transformation is either studied in the history and urban history fields, which mainly focus on historic Hangzhou in periods, such as the Tang, Song, Qing era, and Modern China, or in the urban geography and urban study fields, which center on contemporary Hangzhou. Furthermore, scholars have made some temporal 'slices' within historic periods, such as the Southern Song [37], the Ming and Qing [28], the later Qing to the Republic of China (1910s–1940s) [24], and the post-reform era [26], among others.

In terms of this situation, we endeavor to explore the possibility of exploring Hangzhou's urban transformation in a continuous way, namely from as early as the South Song Dynasty to the present day, rather than in a sectional way as other studies take. We argue that it is by sequential scanning and diachronic viewing that the transformation mechanism and sustainable development of Hangzhou's urban structure be distinctly demonstrated.

Thus, to answer the second question, we identify and elaborate on three key transformations of Hangzhou's urban spatial structure since the twelfth century in this article to show how the complicated commercial impetus contributes to the shaping and reshaping of Hangzhou's urban structure. The first transformation occurred in the Southern Song Dynasty when Hangzhou became the capital city and when early capitalist relation of production sprouted. The city was then obscured in history when the Song empire was conquered by the Yuan emperor Kublai Khan. The second one happened in the Qing Dynasty to the Republic of China. Hangzhou, acting as a provincial capital, embraced its revitalization by grasping the opportunity of industrial and commercial development and became the nation's top handcraft manufacturing and commerce center and then a modern industrial and commercial hub. The third one took place during China's reform and post-reform periods [26], when Hangzhou took the tourist and leisure industry as the new urban development driver and successfully integrated its commercial culture with leisure and heritage culture. The analysis of these three transformations constitutes Sections 3–5 of this article, and the date and methods of our study are shown in Section 2 (Figure 1).

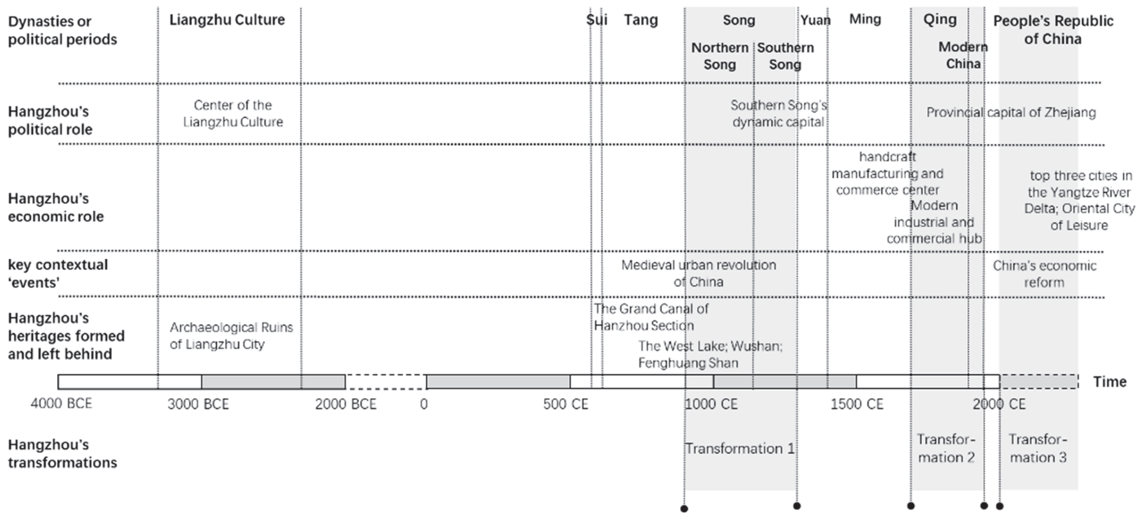


Figure 1. Context of the three transformations of Hangzhou.

2. Data Resources and Methods

Our materials and data for analysis are from four resources. The first resource is classical ancient texts, which illustrate Chang′an, Dongjing, and Hangzhou's economic development, social conditions and transition, and urban pattern and spatial structure during some key historic periods. We sort out the contents from the texts that are related to urban structure and link them with our graphic analysis (Table 1).

Table 1. Classical ancient data resources.

City	Text Name	Author	Time
Tang Chang′an	Gazetteer of Chang′an [38]	Song Minqiu (宋敏求)	1076
	Research of Blocks in Two Ancient Capital Cities (Xi'an and Luoyang) of Tang Dynasty [39]	Xu Son (徐松)	1810
Song Dongjing	The Dream of Hua in the Eastern Capital [40]	Meng Yuanlao (孟元老)	1127
Southern Song Lin'an	Record of Luxuriant Scenery by the Old Man of West Lake [41]	The Old Man of West Lake (西湖老人)	12th century
	A Record of the Capital's Famous Scenic Spots [42]	Ni Deweng (耐得翁)	1235
	Gazetteer of Lin'an from the Xianchun Reign Period [43]	Qian Yueyou (潜说友)	1268
	Former Matters of Wulin [44]	Zhou Mi (周密)	1290
	Dream of Hangzhou [45]	Wu Zimu (吴自牧)	1334
Ming and Qing Hangzhou	The Government Record of Hangzhou from the Chenghua Reign Period [46]	Chen Rang (陈让), Xia Shizheng (夏时正)	1465–1487

The second one is historic maps and painting, base maps, and current satellite maps. The historic maps and painting provide raw spatial structure information about the cities. The base maps are amended through the historic maps, which offer corrected historic urban form and structure. The current satellite maps are from Google Earth, which both provide a base map for analyzing current Hangzhou and a reference for comparing Hangzhou's urban structure transformations in different periods. Based on these maps and information from the ancient texts, we make graphic analysis of Hangzhou's and several ancient cities' urban structure to illustrate the spatial shaping and reshaping of Hangzhou. Specifically, we identify the same spatial elements, such as districts, streets, and complex, during different periods to illustrate the sustainability and transformation of Hangzhou's urban structure (Table 2).

Table 2. Data resources for the urban structuring graphic analysis.

City	Historic Maps or Painting	Base Maps	Satellite Maps
Tang Chang'an	Lv Dafang (吕大防), Chang'an City Map (长安图), 1080 [47]	Cheng Guangyu, Map of Tang Chang'an City [48]	/
	Xu Son, Map of the Western Capital, 'Research of Blocks in Two Ancient Capital Cities (Xi'an and Luoyang) of Tang Dynasty', 1810 [39]		
Song Dongjing	Zhang Zeduan (张择端), Riverside Scenes at the Qingming Festival (清明上河图), 1101 [49]	/	/
Southern Song Lin'an	Qian Yueyou, Map of the Southern Song Capital Lin'an, 1268 [43]	Cheng Guangyu, Map of Southern Song Lin'an City [48]	/
Qing Hangzhou	/	Zhejiang Map Bureau, Map of Zhejiang Provincial Capital, 1892 [50]	/
Hangzhou in the early twentieth century	/	Shanghai Bolan Publishing House, Latest Hangzhou City Map: Full Map of West Lake, 1947 [50]	/
Contemporary Hangzhou	/	The Office of Hangzhou Municipal Government, Map of the Eight Districts of Hangzhou [51]	Google Earth

The third one is the point-of-interest (POI) data. We use Python code to crawl POI data from Gaode Map in Hangzhou's core urban area, namely Shangcheng District, Gongshu District, and Xihu District, in November 2022. The data collected include information about the name, latitude, longitude, and type of POI. According to the POI classification code of Gaode Map and our research needs, the sub category of shopping centers or commercial complexes under the category of shopping services is chosen as the object of analysis. Through screening, deduplication, rectification, and spatial matching, a total of 49 commercial complexes are obtained. Some of the commercial complexes' positions are marked in Section 5.1.

The fourth one is critical and up-to-date literature, both in English and Chinese, on Hangzhou's general history and its urban structure transformation in various periods.

3. Transformation 1: Lin'an in the Southern Song Dynasty, 1137–1279

The commercial and civic culture that drove Hangzhou's first urban structure transformation took shape within the emerging early capitalist relation of production in Song China when the country reached a peak of commercial prosperity. The culture instantly casted their influence on the Song cities, particularly the two capital cities, the Northern Song Dongjing and the Southern Song Hangzhou, which was renamed Lin'an in 1129 CE. The two Song capitals formed sharply different urban structure from the Tang capital Chang'an.

3.1. General Urban Structure before and after the Song Dynasty

In accordance with the emerging early capitalist relation in China, urban structure changed from an enclosed Li-Fang system to an open and free Fang-Xiang system during the mid-Tang to the Song dynasty [6]. A comparison between these two systems is necessary to comprehend Hangzhou's first transformation.

3.1.1. Li-Fang System

China's general urban structure before the Song Dynasty was called Li-Fang system, which consisted of enclosed and distinct urban wards or 'Fangs', rectangular in shape and encircled by walls. All functional areas, such as the neighborhoods and marketplaces, were, respectively, settled within the Fangs. No gates except main entrances of Fangs and of aristocrats' houses and Buddhist monasteries could be set on such walls. Inside the Fangs, the first-grade internal crisscross roads called 'Jie', which opened onto the Fang's four main entrances, and the second-grade roads called 'Qu' further divided a Fang's interior space into multiple sectors. Along these roads, the gates of the ordinary residences or shops could be set up. People passed in and out the Fang through the four Fang's entrances or gates, which were opened and closed at a fixed time every day. In this way, the spatiotemporal design of the Fang facilitated the imposition of a dusk-to-dawn curfew to its residents or merchants and of the emperor's control on them (Figure 2).

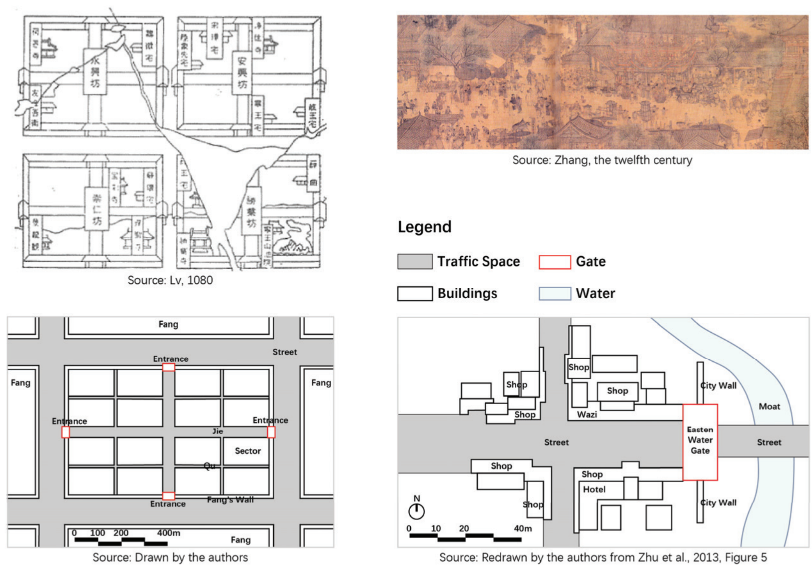


Figure 2. Typical spatial structure of the Li-Fang system (**left**) and of the Fang-Xiang system (**right**) [47,49]. Note: The non-English terms in the historic map of the top left corner are the names of the Fangs and houses.

However, as early as in the mid-Tang (approximately in the ninth century), there were breakthrough indications of the enclosed system due to the accelerating commercialization [4] or the development of commodity economy. Yangzhou, the primary commercial city of the mid-Tang, perfectly exemplified an intermediate stage of a gradual changing or transforming process: the separate market areas and residential areas, which were previously, respectively, fixed into the wards, began to merge together, and an open urban commercial net and border-free neighborhoods were taking form.

Skinner [4] innovatively coined an influential concept, the 'medieval urban revolution' of China, to illustrate such key institutional changes, which began in the mid-Tang and culminated during the Southern Song. To him, a key feature of this revolution was 'the disappearance of the enclosed marketplace, along with the walled-ward system, and their replacement by "a much freer street plan in which trade and commerce could be conducted anywhere within the city or its outlying suburbs"' [4]. Likewise, Lincoln [1] recognized this change as the 'Tang-Song transition' on urban civilization, which occurred from the ninth to the twelfth centuries.

3.1.2. Fang-Xiang System

The most visible outcome of the Tang-Song urban revolution or transition was the replacement of the enclosed Li-Fang system with an open and free Fang-Xiang system or ward-lane system. The spatial structure of Northern Song Dongjing, which meant 'eastern capital', as differentiating from the 'western capital' Chang′an, was a prime example of Fang-Xiang system [9], as the Northern Song Dynasty 'witnessed the most rapid economic growth in the history of China' [22]. Contrary to the Li-Fang system, the spatial structure of the Fang-Xiang system featured the disappeared Fang's walls; the scattered shops and stores, as well as the residences of common people, along the streets, lanes, bridges, waterfronts, among others, to all over the city; and the substitution of the concentrated marketplaces with a well-developed urban commerce net. These changes were notably recorded by the Song litterateur Meng Yuanlao in his masterpiece *The Dream of Hua in the Eastern Capital*.

Although both the mid-Tang and Song China shared the process of institutional urban restructuring, the rise of a civil culture during the Song era as a companion of the then matured prosperous commodity economy made it different from the Tang era. New markets, wine shops, theaters, and teahouses sprang up like mushrooms in the new urban space of Song cities to cater to people's huge recreation and consumption demands under the rising civil culture. Song Dynasty artist Zhang Zeduan's marvelous painting *Riverside Scenes at the Qingming Festival* depicted a bustling scene of such civil culture, urban life, and new urban space at the Qingming Festival in Dongjing in detail [49] (see Figure 2). By contrast, the enclosed traditional urban space only reflected the emperor's will and facilitated the governments' administration but restricted urban life in terms of time and space.

3.2. Comparison between Chang′an and Lin'an

A comparison between Chang′an, the capital of the Tang Dynasty, and Lin'an in the following aspects would be helpful in understanding the Tang-Song dramatic but gradual changes promoted by the commercial culture.

- City name

The names of the two cities implied completely opposite meanings: while Chang′an referred to a permanent resting place, Lin'an, or in Marco Polo's word, Quinsay, referred to 'a temporary resting place' [22].

- Urban planning

Chang′an, then known as 'Daxing', was totally newly planned in the Sui Dynasty (518–619 CE) within the Li-Fang system with strict grid. By contrast, Lin'an was reconstructed on the basis of the capital of Wuyue Kingdom (907–978 CE), which was economically developed, less planned, and had a flexible urban spatial pattern featured by long and narrow blocks along rivers [52].

- Markets and subsidiary facilities

Chang′an has two marketplaces: Dongshi (the Eastern Marketplace) and Xishi (the Western Marketplace). According to the Song scholar Song Minqiu's *Gazetteer of Chang′an*, both covered two Fangs' area, which was about 900 × 900 m. Dongshi largely contained luxury stores that mainly served the royal family and aristocrats as it was close to the royal palace and Fangs where aristocrats lived. By contrast, Xishi targeted common people and 'international' merchants. It also included a large quantity of foreign shops run by international merchants, including the Sogdians, Arabians, and Persians.

In contrast to Chang′an, Lin'an had a complicated trade and recreational system consisting of commercial districts, streets, and professional trade streets. Three integrated commercial districts were distributed from south to north along the Yujie or the Imperial Way, a three-mile long central axis of Lin'an [6], and each took different functions. The southern district, close to the Imperial Palace and the national central administrative district, was an upscale commercial district including upmarket restaurants. The middle district, the largest in Lin'an, had been around since the mid-Tang era and sold a full range of goods. The northern district converged all kinds of leisure and entertainment venues. In addition to these comprehensive districts on the Imperial Way, there were commercial streets for retail, and all kinds of professional trade streets served the guilds stretching along other main urban traffic axes and rivers. Among the professional trade streets, the wholesale ones were adjoined to the land gates and water gates of the city. A large warehouse area was shaped in the northwest part of the city, near the water and land transportation hub [6].

- Recreational places

Chang′an's recreational places were mainly Xichang or theater fields in the marketplaces of Dongshi and Xishi and in Buddhist monasteries, such as Ci'en Temple and Qinglong Temple. Similar to the residences and shops, monasteries were also fixed in Fangs [6].

However, under the boom of commercial and civil culture, Lin'an established grand public complexes called Wazis or Washes, which accommodated varied recreational facilities and activities [53]. According to the *Gazetteer of Lin'an from the Xianchun Reign Period* and *Dream of Hangzhou*, there were 17 Wazis in Lin'an [45,54]. Mimicking Dongjing, the birthplace of the Wazi, these grand complexes were mainly located either along the Imperial Way or outside Lin'an city but adjoined the city gates, namely where people converged. According to the Old Man of West Lake 's *Record of Luxuriant Scenery by the Old Man of West Lake*, Lin'an's largest and most comprehensive public complex was called Bei Wa or Northern Wa in the northern district. Other grand Wazis, like Da Wa (big complex), Zhong Wa (central complex), and Nan Wa (southern complex), lined the central axis.

- Scenic areas

Buddhist monasteries were common scenic areas for Chang′an's civilians to visit. According to Xu Song's *Research of Blocks in Two Ancient Capital Cities of Tang Dynasty*, for example, Ci'en Temple was famous for its peonies, which were flooded with people every spring. In addition, the eastern suburb and southern corner of Chang′an featured beautiful nature landscape. While the eastern suburb was occupied by aristocrats and bureaucrats' villas and gardens, the southern corner was open to the public. However, Qujiang Pond and Furong Park, two of the most famous public views at the southern corner, were situated within the Fang-like marketplaces and neighborhoods.

Contrary to Chang′an, Lin'an's natural landscape such as the West Lake was stretched freely outside the city wall to the west of the urban area. Inside the city wall, hills, like Wushan and Fenghuang Shan, together with the 'open and "participatory" lake' [33] and the urban inland waterway, constituted an interpenetrative Shan-Shui or mountain–water natural and urban landscape of Lin'an. Jia [33] called this landscape a 'paradigm' in Southern Song Lin'an, namely 'a free combination of an artificial urban texture and a natural environment', which strengthened the development of urbanization and commercialization. Thereafter, such a combination remained as one of the critical heritages and features of Hangzhou until today and performed a vital role in making Hangzhou a scenic city and one of the most famous tourist destinations in China since the early twentieth century [31] (Figure 3 and Table 3).

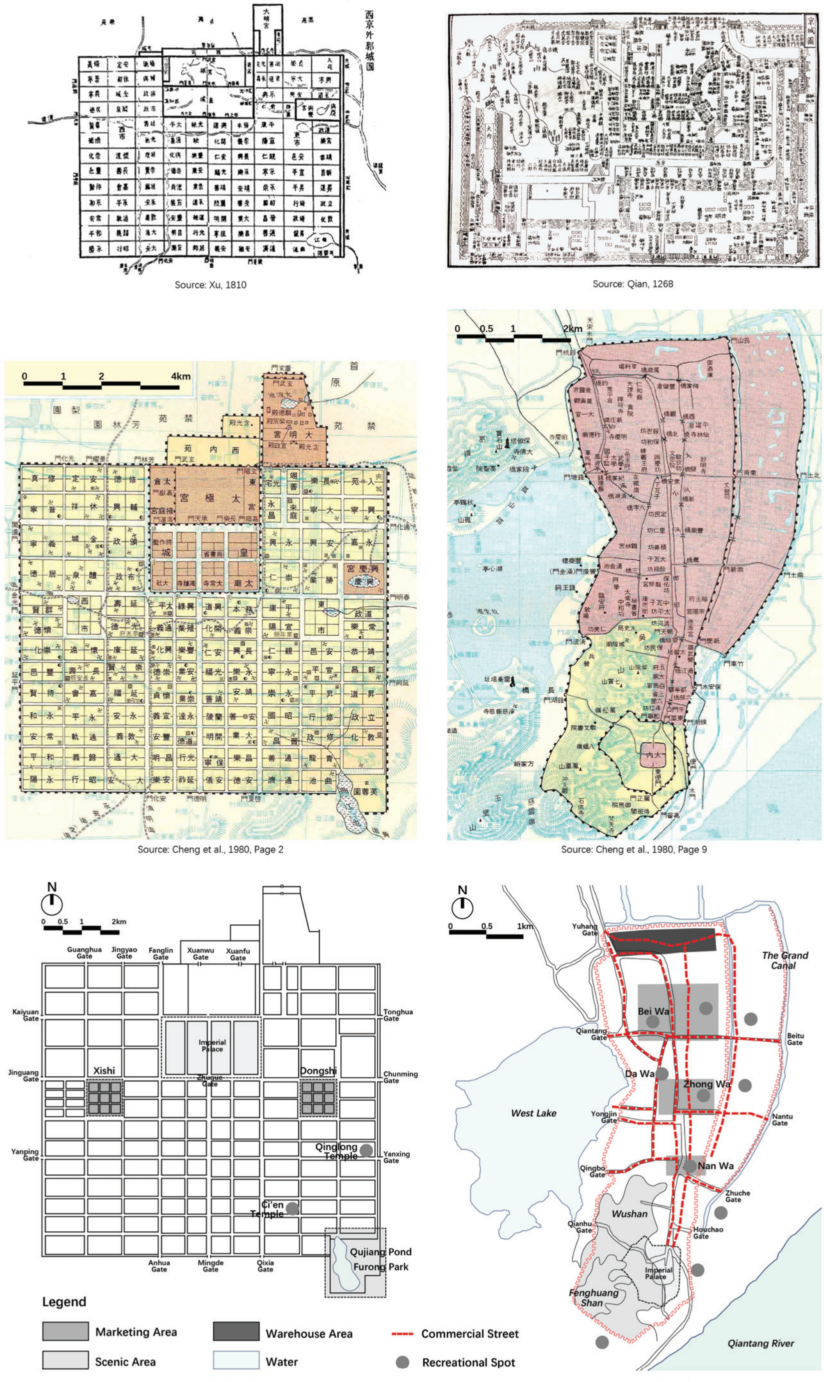


Figure 3. A comparison of Tang Chang′an (**left**) and Southern Song Lin′an (**right**) [39,43,48]. Note: The non-English terms in the historic map of the top left, right corners, and of the middle, are the names of the palaces, Fangs, streets, rivers, lakes, and houses.

Table 3. Comparison between Chang′an and Lin'an.

	Tang Chang′an	Southern Song Lin'an
Role	Capital city of the Tang Dynasty and other twelve dynasties	The Southern Song's capital city
Urban structure	An enclosed Li-Fang System	An open and free Fang-Xiang system
Marketplaces	Dongshi and Xishi	Three integrated commercial districts; commercial net stretched all over the city
Recreational places	Xichang in the marketplaces and Buddhist monasteries	Wazis
Scenic areas	Buddhist monasteries; Qujiang Pond and Furong Park	The West Lake, Wushan and Fenghuang Shan

4. Transformation 2: Hangzhou in the Qing Dynasty and the Republic of China, 1636–1940s

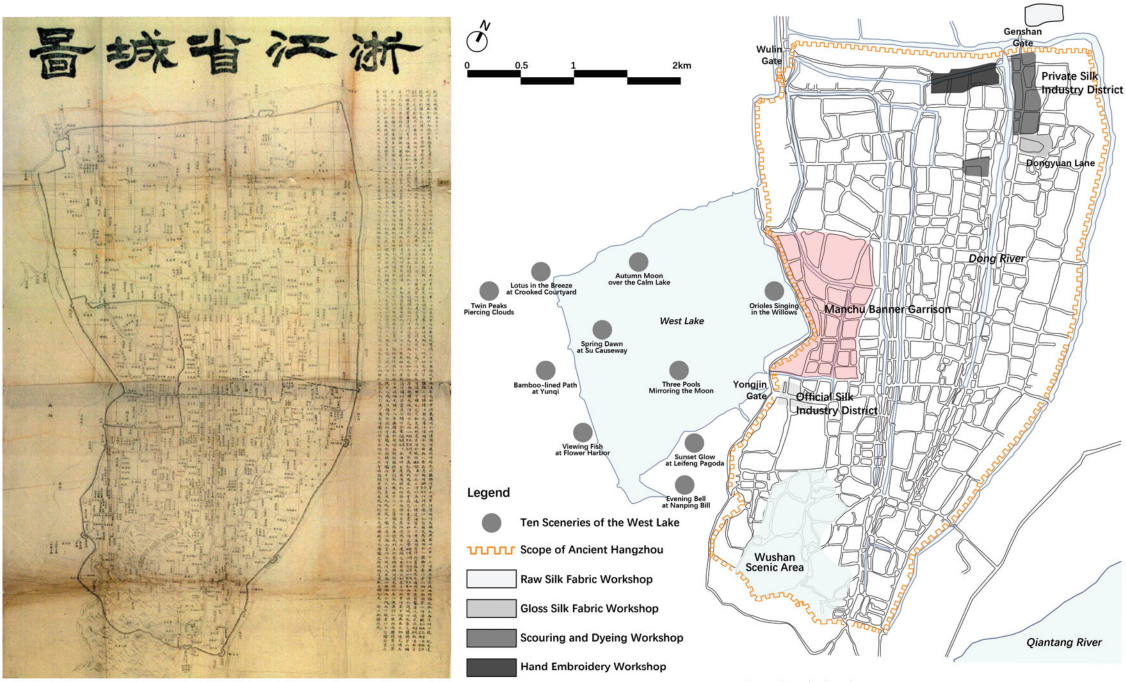
Commercial and leisure culture, which was formed under the industrial and commercial development in late imperial China [4,55], promoted Hangzhou's second transformation, following the commercial and civic culture under the early capitalist relation of production in mid-imperial China during Hangzhou's first transformation. Specifically, two forces for the second urban restructuring could be distinguished. The first was the silk and tea culture in the Ming and early Qing time when Hangzhou was a national hub of handicraft production and trade. The second was the modern industrial, commercial, and landscape culture in the late-Qing and early twentieth century when Hangzhou, together with Suzhou and Nanjing, had to take back seats as Shanghai gradually evolved as the prime city of China's modern industry, economy, and trade from the late nineteenth century.

4.1. Hangzhou in Ming and Early Qing Dynasty

After the Yuan defeated the Southern Song, Hangzhou fell into a trough of political status and economic development due to natural and man-made disasters such as the war [56]. Politically, its status as a dynamic capital was lost as Beijing, and temporarily Nanjing, succeeded it to be the capital city. Instead, it was downgraded to a the local political center of China, namely the provincial capital of Zhejiang province, in the early Qing era in 1662 CE until today. Economically, it was not until the Ming Dynasty when Hangzhou gradually recovered as a hub of trade and commerce in the Lower Yangzi region, as it was the southern terminus on the Beijing–Hangzhou Grand Canal, the economic artery of the Song through to Qing empires. It came to be the biggest one of the three Imperial Silk Production Bureaus or Weaving and Dyeing Offices during the Qing (the other two Bureaus were located in Nanjing and Suzhou) [55], as estimated in output [23], and one of the top cities for handcraft manufacturing and commerce [31]. Meanwhile, other handcrafts and commercial cities competing with Hangzhou proliferated, especially from the mid-Qing era. Therefore, Hangzhou was hardly a trend leader in urban transformation and culture, especially since the mid-nineteenth century when the Taiping rebel outbroke [31]. However, its industrial combination of textile and clothing industries featured by silk production and leisure industry featured by tea production and consumption could still ensure its uniqueness among similar cities.

4.1.1. Silk Culture as the Commercial Culture

As early as the Song Dynasty, systematic market divisions had been made between the comprehensive and professional and between wholesale and retail [57]. During the Ming and Qing Dynasty, market division had been more sophisticated as a market system than before. This trend was exemplified by the locations of Hangzhou's official and private silk industry and trade districts. The official district was located in the west of the city, especially gathering at the downtown area inside one city gate, the Yongjin Gate, while the private one was in the north of the city and could be sorted into two categories. The private workshops at Dongyuan Lane produced gloss silk fabric. Those out of the Genshan Gate, another city gate, produced raw silk fabric. As parts of the silk industry chain, scouring and dyeing workshops were situated on both shores of Dong River, ranging from the area of gloss silk fabric workshops to the area of raw silk fabric workshops. In addition, hand embroidery workshops gathered at the western side of those dyeing workshops (Figure 4). These two districts, together with the wholesale and retail silk stores scattered near them, formed a network of Hangzhou's silk manufacturing and trading.



Source: Zhejiang Map Bureau, 1892

Source: Drawn by the authors

Figure 4. The late-Qing Hangzhou's map (**left**) and its silk industry districts and scenic spots (**right**) [50]. Note: The non-English terms in the historic map on the left are the names of the map, streets, rivers, lakes, and houses.

4.1.2. Tea Culture as the Leisure Culture

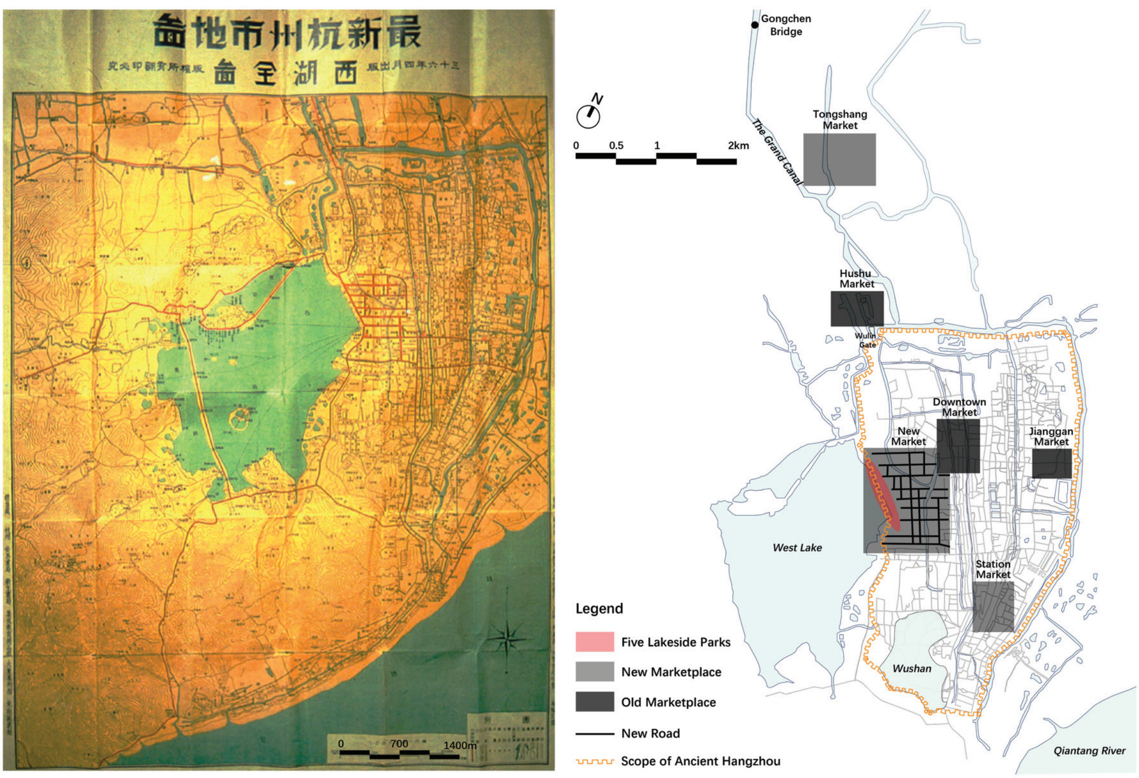
Tea culture, one of many Chinese or Eastern Asian leisure cultures, also flourished at the time. Hangzhou was the primary producing area of Longjing (Dragon well) tea, one of the five superior types of tea in Ming China [58]. As a result, teahouses slowly replaced Wazi as a public entertainment spot. However, teahouses differed from Wazi in three aspects. First, a teahouse's main functions were information exchange and deal clinching but not as comprehensive as those of Wazi. Second, there were entertainment activities displayed every day in teahouses, but traditional drama performances from Wazi were transferred to theaters. Third, tea tasting and tea culture were considered elegant and associated with the upper elites and literati, while entertainments in Wazi were often regarded as popular or even vulgar. Wu Zimu even commented, in Volume 19 of the *Dream of Hangzhou* by citing the Song scholar Ni Deweng's *A Record of the Capital's Famous Scenic Spots: Performers of the Washe* (都城纪胜·瓦舍众伎), that the Wazi was 'a place of bohemianism for both the elites and common people' (士庶放荡不羁之所). Wushan or the City-god hill supplanted the scattered Song Wazi as Hangzhou's major commercial and popular entertainment area for the common people in the late-Qing time due to its religious status, which conglomerated the city-god temple and many other Buddhist and Daoist temples and, thus, conglomerated the people [31].

4.2. Hangzhou in the Late-Qing and Early Twentieth Century

The urban structure of many Chinese cities, including Hangzhou, was fiercely reshaped in the late-Qing time when Western and Japanese colonists forced the Qing government to open the doors of the country and when China's modern industry began to develop. In 1895, Japan forced the Qing Government to sign the unequal Treaty of Shimonoseki. Hangzhou was among the list of China's open treaty ports according to the Treaty. On one hand, it marked the beginning of the semi-colonial process of Hangzhou. On the other hand, it paved the way for Hangzhou's development of modern capitalism and industry. The mushroomed modern industrial area in Gongchen area and along the Grand Canal, together with the establishment of a lakeside business district called the New Business District in 1913, largely changed Hangzhou's urban pattern, since ancient times, as it further set free the previously enclosed urban space.

4.2.1. Modern Industrial and Commercial Culture

Hangzhou formed three 'old' marketplaces in the late-Qing era, namely the Downtown Market, which served the bureaucrat, the Jianggan Market, and the Hushu Market area. Three new ones, namely the Tongshang Market, the Station Market, and the New Market, gradually took shape from the late nineteenth to the early twentieth century. Accordingly, these six marketplaces constituted the major modern commercial framework of Hangzhou (Figure 5).



Source: Shanghai Bolan Publishing House, 1947

Source: Drawn by the authors

Figure 5. The early twentieth century Hangzhou's map (**left**) and its old and new marketplaces (**right**) [50]. Note: The non-English terms in the historic map on the left are the names of the map.

Although these three new marketplaces were generated out of different causes, they were all related to Hangzhou's modern industrial and commercial development. After the city was opened as a treaty port, the Japanese established a concession area near Gongchen Bridge in 1896, a vital transport hub on the Grand Canal of Hangzhou section. A comprehensive commercial district named Tongshang Market was then set up south of the Japanese concession [59]. From then, the area around the Japanese concession and Gongchen Bridge and along the Grand Canal became a cradle for Hangzhou's modern industry and commerce, as many national capitalist factories, such as the reeling mill and cotton mill, chose to locate there.

The establishment and naming of the Station Market should be attributed to the opening of a newly constructed railway between Hangzhou and Shanghai in 1911, as it was formed near the railway station.

After the 1911 Revolution, troops of the Qing Government in Hangzhou surrendered. In 1913, the newly composed government planned to dispose all the land of the Manchu banner garrison, the former military fortress and residential district of the Qing's Manchu troops, and to build a new center of tourism and commerce called the New Business District to supplant the old commercial district around Wushan [32]. With the New Business District plan carried out in 1913, a lakeside market called New Market emerged.

4.2.2. Landscape Culture

The West Lake had already been famed for its 'world famous sceneries' in the Song Dynasty, as recorded in the Song scholar Zhou Mi's *Former Matters of Wulin*. It was revitalized in Qing Dynasty as the Song's scenic and cultural heritage when Emperor Kangxi (1654–1722 CE) standardized the 'Ten Views of West Lake' originating in the Song [25]. Emperor Yongzheng, son of Kangxi, nominated an additional eighteen sceneries, which indicated that the scope of the West Lake as a scenic area was enlarged greatly. Emperor Qianlong, son of Yongzheng, wrote at least five series of poems on the Ten Views [25]. Although the purpose of the three emperors was to coopt and administer the Jiangnan Han literati through patronizing the West Lake, the core of the Jiangnan region [25,31], the three emperors' endorsements formed Hangzhou's initial landscape culture made the city one of China's leading tourist destinations from then on.

With the implementation of the 1913 plan, the city walls between the West Lake and the city were demolished. As a result, the lake was, for the first time, merged into the urban area. New lakefront roads were built on the original sites of the walls. In addition, former roads in the Manchu banner garrison were completely abandoned, and a new straight road system was designed and built, which was quite inharmonious to the city's original road framework. Furthermore, five lakeside parks were created. About ten years later, this new lakefront area, with a new name of Hubin, meaning the shore of the lake, had developed into a new prosperous 'downtown' with the highest property value in the city. Meanwhile, Hangzhou rose as a tourist city for the new middle class from Shanghai who preferred 'authentic' Chinese culture [25], which was constituted from Hangzhou's leisure and landscape culture.

5. Transformation 3: Present Day Hangzhou, 1980s Onwards

Hangzhou's third transformation occurred in the 1990s, or in the post-reform era since the 2000s [26], when it became one of the top three cities in the Yangtze River Delta region of China. This economic positioning implied that, although Hangzhou's role was secondary to Shanghai ever since the mid-nineteenth century [31], it still remained the major commercial and cultural center in Southeastern China or the lower reaches of the Yangtze River region. The positioning also forged Hangzhou's new commercial culture, which added elements of tourism, leisure, and urban heritages and further boosted the urban restructuring of the city.

5.1. New Elements of Commercial Culture

After the founding of the People's Republic of China in 1949, urban structure and elements of commercial culture of Hangzhou continued to evolve. Apart from the preserved elements, some new elements began to emerge after China's Reform and Opening-up policy was released in 1978.

The preserved element was the five commercial districts. They inherited Hangzhou's commercial and cultural heritages as they all had close relationship with one or two of the six marketplaces forged previously, and even the commercial and cultural area originated in the Song dynasty. Among them, Hubin, Wulin, and Wushan commercial districts were formed after the 1980s. With the release and implementation of the 'Hangzhou Master Plan (2001–2020)', two new commercial districts, i.e., Gongshu and Jianggan, were added (Table 4).

Table 4. Hangzhou's commercial districts formed after the 1980s and their relations with the previous marketplaces and urban heritages.

Marketplaces in the Twentieth Century	Commercial Districts after the 1980s	Functions of the Commercial Districts	Urban Heritages
Downtown Market	Wulin District	Modern service industries like business, finance, securities, among others	Named after the name of Hangzhou's major northern gate in Ming Time, Wulin Gate, which was called Yuhang Gate in the Southern Song
New Market	Hubin District	Leisure, tourism and upscale shopping	Inherited Hangzhou's prosperous downtown's business of the early twentieth century
-	Wushan District	Traditional or historical culture and commerce.	A commercial and cultural area originated in the Southern Song Dynasty
Tongshang Market	Gongshu District	Tourism and mass consumption	Modern industrial heritage along the Grand Canal
Hushu Market			
Jianggan Market	Jianggan District	Smart commerce and retail	An eponymous district of the early twentieth century market but had different location
Station Market			

One new element was professional commercial streets, which severed diverse trade and retail and became new highlights of Hangzhou's modern commerce. From the 1990s, eighteen special commercial streets, including silk streets, clothing streets, tea culture villages, and so on, were established. Some streets were well known for selling special products, such as Wulin Road featuring women's dress, Wensan Road featuring digital products, and Qiutao Road featuring home furnishing. Some provided catering, recreation, and refreshment, such as Shuguang Road and Nanshan Road. Tourists could enjoy themselves in some specialty bars and restaurants on these streets. Some others, like Hefang Street near Wushan Scenic Area, were characterized by their culture and profound history, which show the local attraction and national and historical characteristics. The other kind of new element was the mushroomed commercial complexes ever since the 2010s, which contained all kinds of shopping and recreational facilitates. These commercial complexes, as spread across the urban area, attracted many people, and they function as the Song Wazis of the present day. However, they differed from the Wazis in their more even spatial distribution and accessibility (Figure 6).

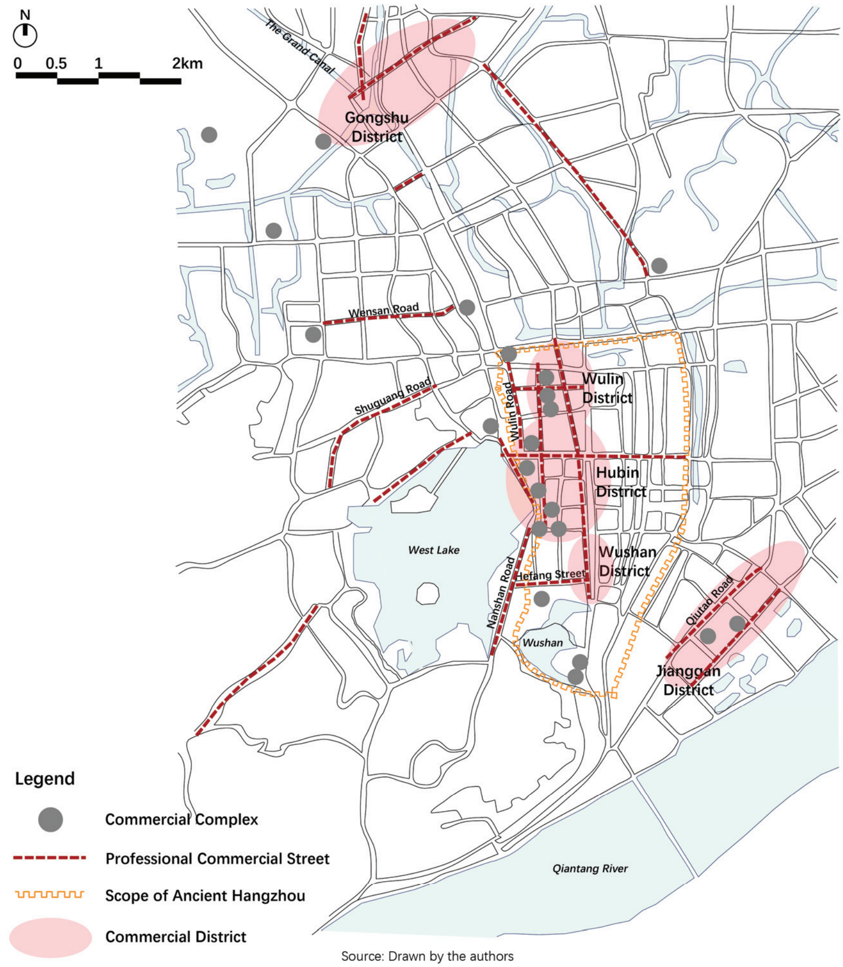


Figure 6. Commercial districts, streets, and complexes in contemporary Hangzhou.

5.2. Leisure and Heritage Culture

Hangzhou immediately combined its commercial with tourism development, leveraging China's recognition of the tourism industry as a key driver of economic growth in the 1990s. The city rapidly ascended to become one of China's most renowned scenic tourist destinations and was labelled as an 'Oriental City of Leisure' by the World Leisure Organization in 2006 [60].

To cater to the increasing influx of tourists and visitors, Hangzhou, as a prominent tourist destination and leisure city, strategically expanded its range of commercially valuable scenic areas. In addition to the cultural landscapes and also urban heritages, such as the West Lake and Wushan, the cores of leisure and entertainment in the Song and Qing, some new tourist attractions have emerged during the past two decades. Xixi Wetland, the waterfronts of Grand Canal of Hangzhou Section, and Archaeologic Ruins of Liangzhu City were the three best practices, which exemplified Hangzhou's alternative path in commercializing its natural and heritage resources to develop its tourist industry and its role as an Oriental City of Leisure, both of which were key factors in shaping the commercial culture.

Xixi Wetland, a natural landscape for ecological recreation, was one of the key elements in pushing Hangzhou's tourist industry westwards. After the West Lake Cultural Landscape of Hangzhou was nominated as the city's first World heritage in 2011, the over-1500-year-old Grand Canal as the second in 2014, and Liangzhu prehistoric ruins as the third in 2019, promoting the city's scenic territory to develop westward and northward (Figure 7).

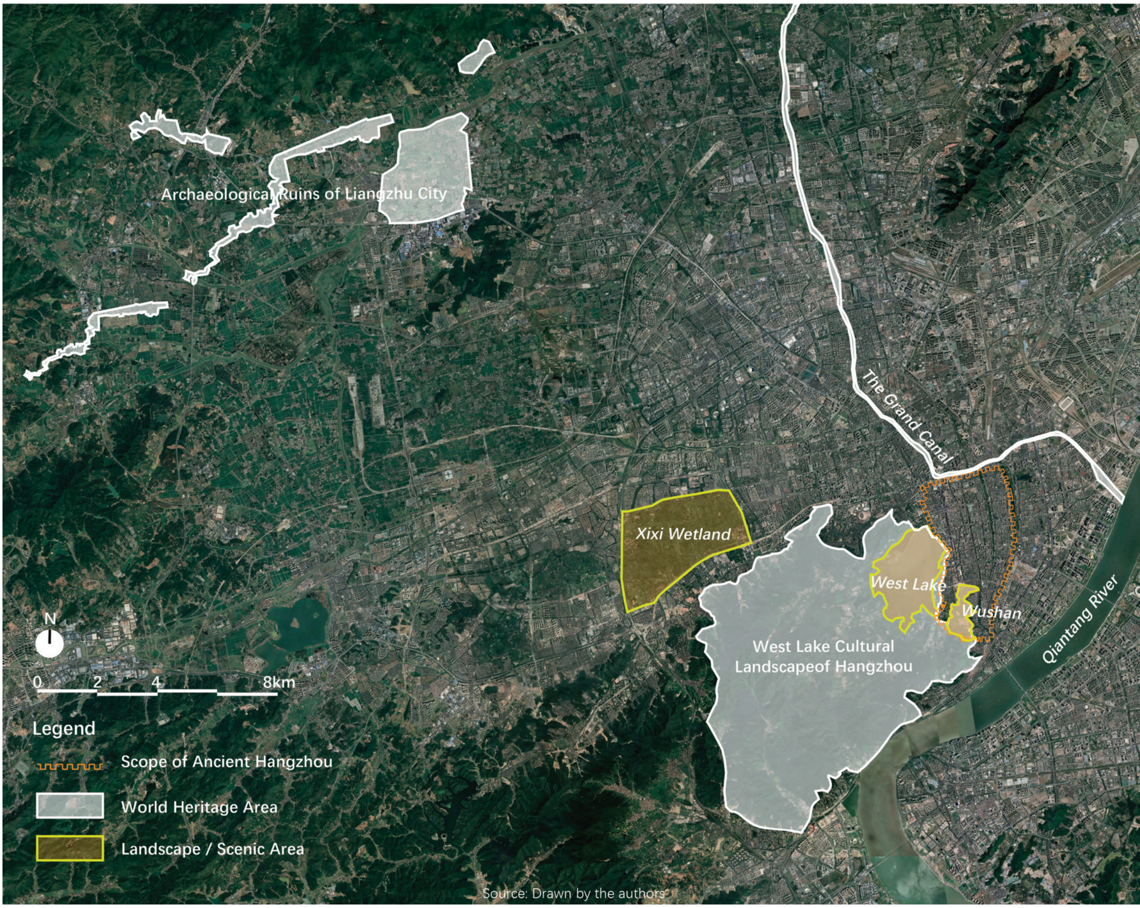


Figure 7. The distribution of Hangzhou's natural and heritage resources.

A series of measures were implemented to enhance national and even international recognition and commodity value of these heritages and resources. The first measure was function transformation. For example, Hangzhou municipal government has undertaken a comprehensive transformation program for the canal, focusing on reducing its emphasis on water transportation and instead integrating leisure and cultural functions to create a vibrant tourist corridor. The second was undertaking various cultural events, like making films, which took the landscape as the movie location, and holding cultural festivals. The third was developing tourist and commercial facilities, such as theme parks, museums designed by world-famous architects, and recreational street blocks, among others. The Wetland Museum, for instance, was designed by the Pritzker Architecture Prize winner (2019) Arata Isozaki and Liangzhu Museum by the Pritzker Architecture Prize winner (2023) David Chipperfield. From one aspect, these measures facilitated the commercializing process and sustainability of the urban heritages and resources. They, from another aspect, enriched the diversity of Hangzhou's commercial and leisure culture, expanded the city's tourism and leisure space and, ultimately, reshaped its urban structure.

6. Conclusions

Urban structure formation and transformation are interesting but broad topics, which have been abundantly studied. Quite a few studies focus on the political or institutional factors [3,6,27], economic reasons [4,22,28], cultural and religious dynamics [58,61], or even the natural and cultural landscape factors [24,25,31,33] as the main drivers for the urban restructuring of Chinese cities. Among these studies, various dynastic capitals are abundantly studied as the cases of China's historical urban structuring and restructuring [6,8,9,14,53,62]. Local Chinese cities, as regarded as supporting roles in this structuring process, remain to be fully studied [52,57]. The dynamic evolution of a once-capital local city, or what we call a multi-identity city, has been rarely studied. In addition, considering the historical and contemporary impact of commerce in shaping various urban forms, it appears that the field of knowledge is still quite incomplete.

Considering the state of the art and deficiencies in current studies, we chose to approach the topic of the urban structuring mechanism by studying Hangzhou, a multi-identity Chinese city, which, we argued, could hardly be studied through either political or economic perspectives. Through data analysis of classic ancient texts, historical maps and painting, critical and latest studies, and POI data, we explored Hangzhou's internal evolving mechanism and argued that its intricate commercial culture played a pivotal role in continuously shaping and reshaping Hangzhou's urban spatial structure.

Under a diachronic view, we distinguished Hangzhou's three major spatial structural transformations. Each was, respectively, driven by the mixed commercial culture with other elementary cultures, such as the civil, leisure, landscape, and industrial. The transforming and sustainability process, in turn, we argued, enriched the city's complicated commercial culture. Our main findings are summarized as follows (Table 5).

Table 5. Comparison between the three transformation stages of Hangzhou.

	Transformation 1	Transformation 2	Transformation 3
Duration	Southern Song Dynasty	From Qing through to the Republic of China	From the 1990s onwards
Role	The Southern Song's capital	Top national hub of handcraft manufacturing and commerce; modern industrial and commercial city	Provincial capital of Zhejiang province; top tourist destination; Oriental City of Leisure
Social context	Early capitalist relation of production sprouted	Colonization, modernization	China's reform and post-reform
Impetus	Commercial and civil culture	Commercial (silk production, modern industry) and leisure (tea, landscape) culture	commercial culture with leisure and heritage culture
Transformation	From the enclosed to open and free urban structure	The formation of modern marketplaces and the merge of natural landscape and urban area	The emerging of new commercial elements and expanding of the leisure space
Major commercial and recreational areas	Three commercial districts, commercial net and Wazis	Teahouses and Wushan area; six marketplaces and the West Lake	Five marketplaces, eighteen professional commercial streets, hundreds of commercial complexes; three World Heritage and the Xixi Wetland
Changes in urban heritages	The West Lake	The West Lake; Wushan	The West Lake; the Grand Canal; the Liangzhu Prehistoric Site

Additionally, many relevant studies on Hangzhou's urban pattern and structure evolution are qualitative research with no or only raw historic maps and lack a spatial perspective [23,37,56]. By contrast, we introduce and merge the data and information of classic ancient texts and historic maps to display the dynamic transformation of Hangzhou, through graphic analysis of the structuring of the same urban commercial elements, such as the streets, districts, and complexes, generating, inheriting, revitalizing, and reutilizing urban heritages. Through tracing the sequential changes in the same spatial elements on maps, we believe that Hangzhou's shaping and restructuring process is more clearly displayed than through pure text or individual graphics (Figure 8).

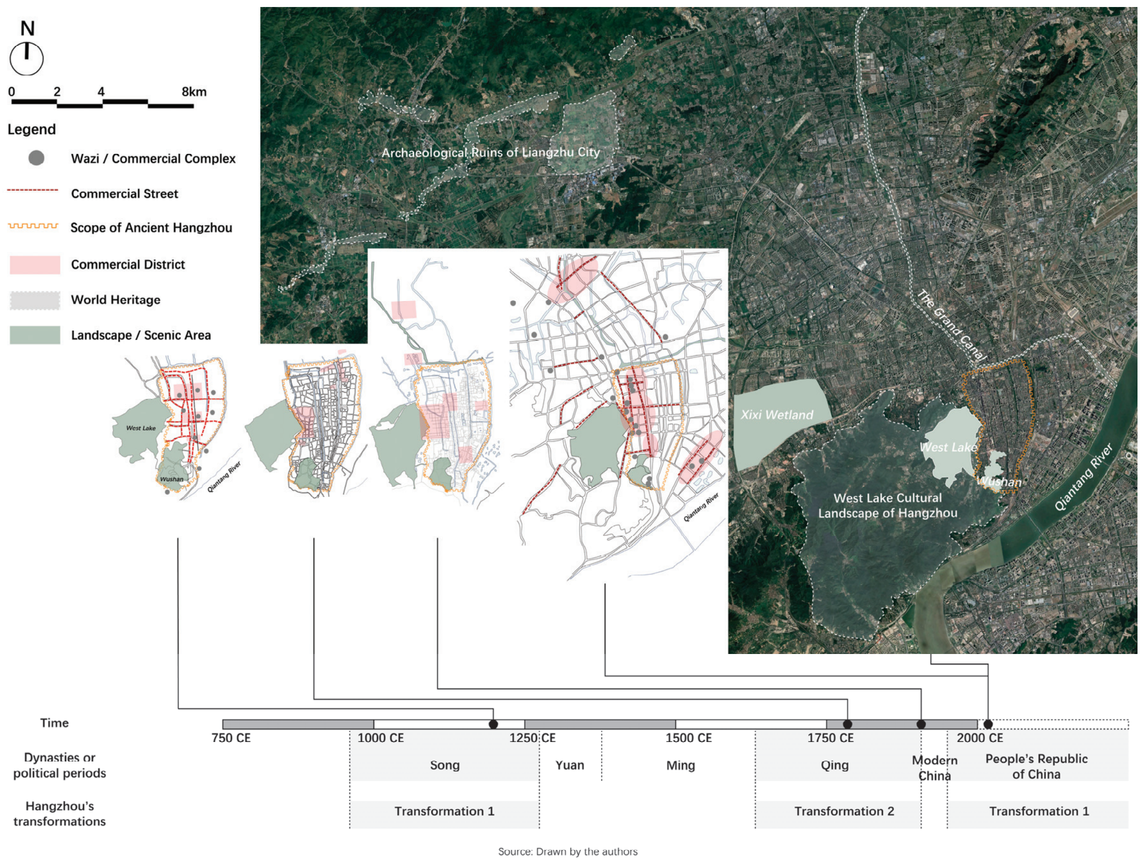


Figure 8. Hangzhou's three transformations.

We believe that Hangzhou serves as a prime example of how a city, even in the absence of a dominant political impetus, can continue to evolve and regenerate itself as a complex commercial hub that influences the entire country. Moreover, the city exemplifies the ability to strategically leverage every available resource and element to enhance its commercial strength and foster a vibrant commercial culture. This dynamic approach serves as the vital driving force behind Hangzhou's ongoing urban development and spatial restructuring. Through a case study of the constant urban structuring and restructuring process of such a city, we wish to trigger more in-depth research on this topic with alternative perspectives and more quantitative data and analysis than this article has applied. Additionally, in terms of the current Liangzhu studies, which are limited within its prehistoric context and period [34–36], we also call for further research, which can link this crucial urban heritage, the very origin of a city, and the city's contemporary urban condition and spatial pattern.

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Data Availability Statement: The data presented in this study are openly available in (https://ctext.org/zhs), reference number [38,40,42–44,46], and in (https://www.zhonghuadiancang.com/), reference number [41].

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Acoustic Tomography as a Supporting Tool in the Sustainable Management of Historic Greenery: Example of the Church Garden in Horostyta (Poland)

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Abstract: Senile trees in historic church gardens have natural, aesthetic, historical, and cultural value. Cutting them down too hastily annihilates the achievements of entire generations. We should try to preserve the greenery surrounding historic churches and integrate it into a clear compositional arrangement with the sacral architecture. The primary purpose of the paper was to describe the process of inventorying 200-year-old trees and to present the revalorization project for the garden around the historic Orthodox church in Horostyta, located in the Lublin Voivodeship, in southeastern Poland. The church complex consists of a wooden 18th-century building, bell tower, garden, and cemetery. Within the church garden's boundaries, there are 15 trees, with two predominant species: *Acer pseudoplatanus* L. and *Tilia cordata* Mill. These trees are of varying ages and health conditions. We used acoustic tomography to perform tree health diagnostics. Three trees, for which the initial visual assessment was disturbing, were examined thanks to detailed tomography tests. Then, through a project adapting the church garden to the health conditions of the ancient trees, they were separated from users by flowerbeds and no small architectural objects were placed around them. The presented development concept forms a compromise between tradition and the modern user's needs. In 2007, a general renovation of the temple building was completed. Currently, the presented project for the church garden is being implemented.

Keywords: acoustic tomography; senile tree; church garden; orthodox church; revalorization; Horostyta Wyryki commune; Poland

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1. Introduction

Academic interest in preserving, maintaining, and restoring historic gardens started in the 1980s when the Florence Charter officially identified historic gardens as "living monuments". Over the last 40 years, garden management methodologies have evolved and become more complex. Historic gardens represent essential nodes in the plots of open-space systems and ecological networks [1]. Gardens are a part of our culture. They "open a window" to the past, and it is hard to rehabilitate or replace the original gardens once they are lost. In Poland, many historic gardens need maintenance, restoration, and conservation, and general improvements in the skills and knowledge of their keepers are also required. The delicate maintenance of senile trees is vital for historic gardens and their conservation.

In some historic gardens, age-old trees can harm people and property. Considering such situations, one should make decisions about the design of the restoration of ancient gardens and the long-term management of vegetation to ensure a functioning, healthy, and safe area for future users [2,3]. Recognition of old and notable tree stands and historic orchards as heritage elements is widely accepted because they are considered valuable elements of "biocultural heritage" [4–6].

Nevertheless, the science of analyzing the stability (statics) of trees makes a vital contribution to public safety by providing, if not perfect, at least an improved method of measuring the stability of trees, thereby increasing the level of comfort from being in their presence [7–9]. Examination of trees using CT scans allows one to look inside the trunk and assess structural changes in the wood much better than only using the VTA method (visual tree assessment). The results show precise information about the size and location of rot, damage, and other defects affecting the tree's stability. The presented acoustic tomography research can be considered innovative in Lublin province.

We carried out observations in the eastern part of the Lubelskie Voivodeship, which borders Ukraine and Belarus. The village of Horostyta is located near Polesie Lubelskie, Łęczyńsko-Włodawskie Lake District, Polesie National Park, Poleski Landscape Park, and Sobiborski Landscape Park. This region is among the least populated in the Lublin region and has one of the highest forestation rates. A natural environment with a wealth of unique fauna and flora specimens, of which various species grow in the adjacent forests, swamps, peat bogs, and vast meadows, surrounds Horostyta. The attractiveness of the place is also influenced by well-preserved architectural monuments associated with a centuries-old tradition, testifying to the cultural and ethnic diversity of the region. In the municipality of Wyryki, these are both secular and sacred objects that testify to the rich and complex history of the area, including the hunting palace of the Zamoyski family, the late Baroque Roman Catholic church in Lubien, residential buildings dating back to the early 20th century, windmills, and the Orthodox church in Horostyta.

Recognizing religion as an essential organizing factor in social life, especially in traditional (rural) communities, various manifestations and forms of religiosity are significantly reflected in the cultural landscape, primarily in material, sacred, landscape elements [10,11]. At present, however, in the landscape of the Polish countryside in connection with the drive to modernize it, some characteristic elements are disappearing, i.e., rural home gardens, church gardens, and small sacred architectures such as shrines and roadside crosses.

Temples, monasteries, necropolises, and other smaller religious objects and symbols characteristic of different cultures differ in form, architectural style, location rules and orientation, and content and symbolism. They are an essential source (carrier) of meaning related to the emotional, intellectual, and utilitarian spheres, which, however, cannot be read without knowledge of specific cultural codes [12,13]. Religious objects are not only places of worship or rituals; they also perform other essential social functions, such as integrating a community, commemorating significant events, and figuring out landmarks. They are also a peculiar expression of the need to "mark" space, "tame" it, and thus define the belonging of an area [14].

One example of interesting buildings in the rural landscape is churches and wooden orthodox churches. These serve as religious buildings and are a crucial element of cultural heritage. The gardens in their surroundings need to be recognized, thoroughly analyzed, and, in further proceedings, revalorized and protected, and recommendations should be developed about how to care for and maintain the old stands [15].

This study set the following research tasks:

1. The primary purpose of this study was to investigate the usefulness of sound tomography for assessing the health of a stand of trees in a historic church garden.
2. Uncertainty about the health of trees can lead to erroneous decisions about stand management. We developed a conservation plan for valuable tree stands and garden projects based on a visual assessment supported by sound tomography surveys. In this way, one can avoid the felling of low-risk trees and prevent possible accidents by removing high-risk specimens.
3. The collected data provided a database of information on the stand's resources and served as the basis for designing the church's surroundings.

The primary purpose of the work was to show the process of taking inventory and revalorizing the surroundings of a historic religious building. While diagnosing the health of the dendroflora, the latest computer techniques, i.e., acoustic tomography, were used. The results made it possible to carry out a revalorization project tailored to the health of the aged trees growing on the property. The critical problem was to develop a plan to develop and maintain a properly functioning garden so that it would be possible to preserve as many trees as possible that are valuable to the environment while adapting the site for safe use. Moreover, while restoring such objects, we must understand the features of the church landscape design, which has been formed and improved over the centuries.

The Stages of the Design Process

We organized the design process in three stages. Firstly, we reviewed the scientific literature and papers. We presented the church's history in Horostyta, described the main guidelines for designing the church gardens, and explained the symbolism used in these gardens. The next stage of the research consisted of visiting the chosen site for measurements and data gathering and evaluating the site's current garden. The last stage of the research consisted of data processing and the final design proposal based on the findings and insights. We used CorelDraw, Sketchup, and Photoshop software to represent the graphical elements. The stages of the design process are presented below (Figure 1).

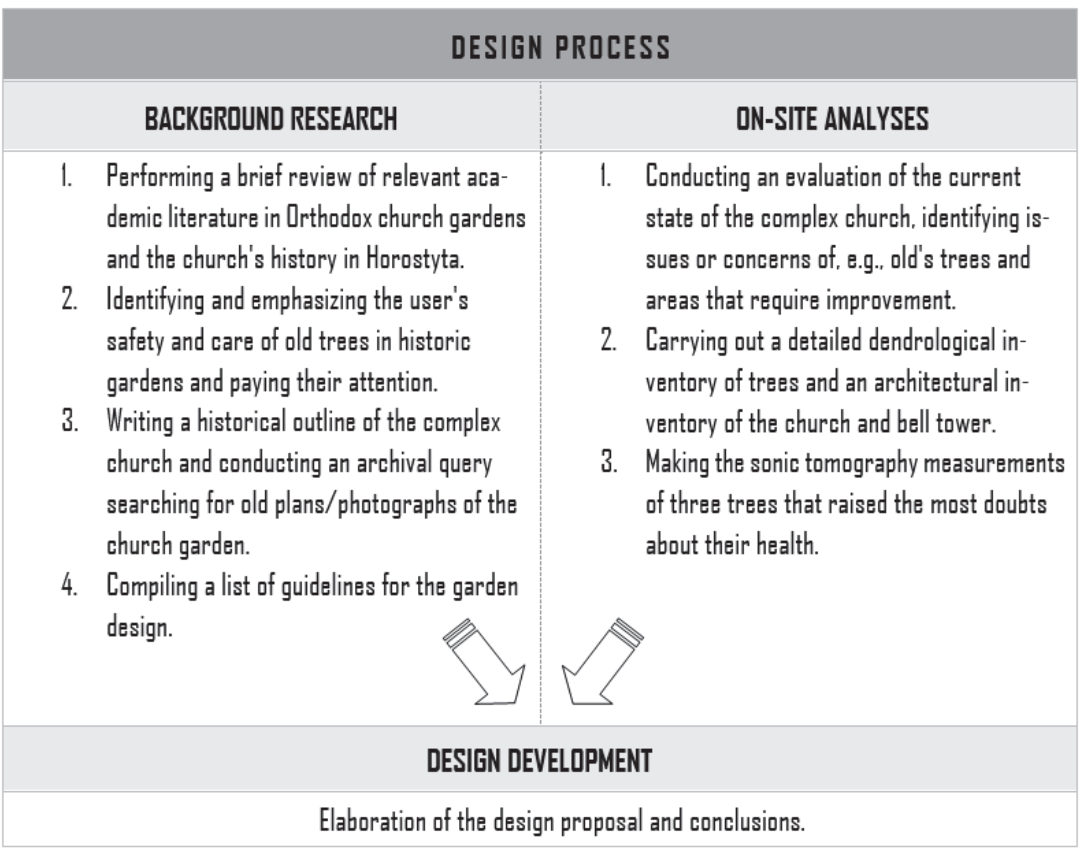


Figure 1. Process of the revalorization project for a historic church garden.

2. Materials and Methods

2.1. Materials

The Orthodox church and belfry, surrounded by centuries-old plantings, are located at the western end of the village of Horostyta (approximately 2100 sqm) (Figure 2). The building of the Orthodox church, together with the interior and exterior furnishings and belfry, is included in the list of monuments of Lubelskie province under No. A/143 [16]. A historic tree stand surrounds the church, which includes 15 trees of various ages and health, including two natural monuments. A brick wall and part of an old fence outline the area. Cast iron, stylized lanterns illuminate the whole area. Within the property's boundaries, along the fence and on the side of the municipal road, there are two wooden crosses and one metal cross. A wooden cross and a stone slab commemorating the January Uprising (1863) are on the church's northern side. A procession road runs around the church, and the temple dominates this small plot. Its architecture fits very well into the rural surroundings of the village, as does the free-standing bell tower. The parish house is on a separate plot north of the church.

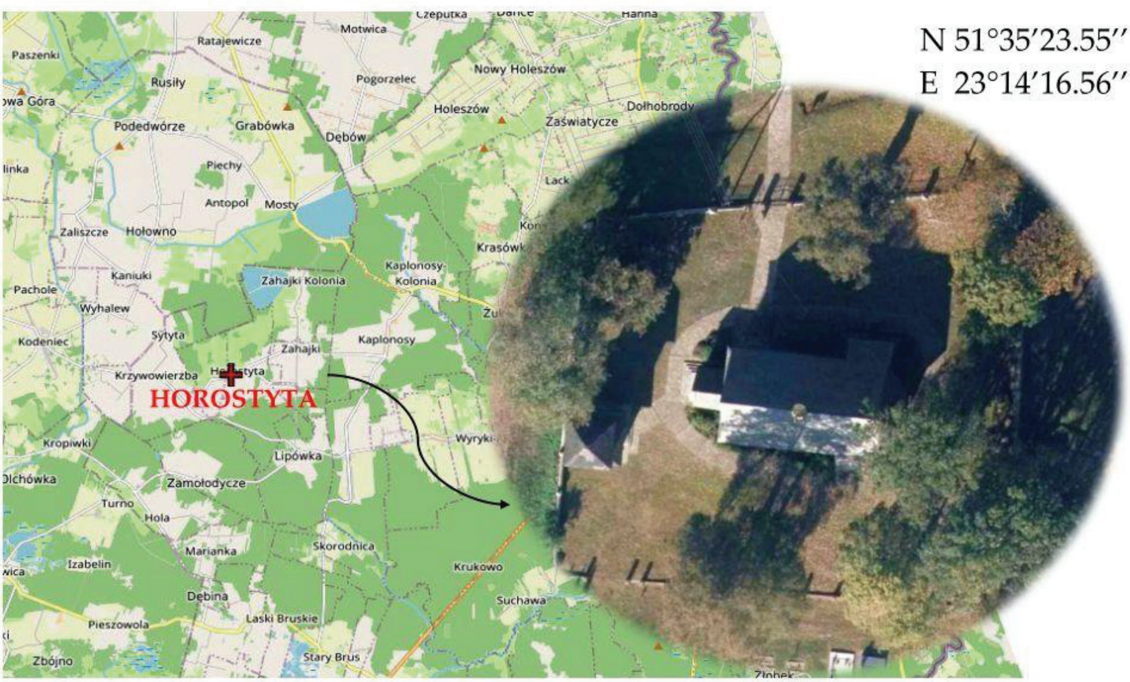


Figure 2. Geographic location of the study area (https://polska.geoportal2.pl/map/www/mapa.php?mapa=polska, accessed on 1 February 2023 (by authors).

Gardens around religious buildings were often created in previously developed areas for cemeteries. However, these necropolises were mainly relocated outside temples in the 18th century for sanitary reasons, among others. The tendency to locate cemeteries within churches dates back to the 10th century, coinciding with concern for burials to occur on consecrated ground [17]. The location of the former church cemetery is also marked around the temple in Horostyta. Today, the burial place is on the south side of the church building, in the cemetery about 100 m from the church.

2.2. Methods of Dendrological Measurements

During the field research, we made a dendrological description of all trees in the study area. The dendrological research consisted of a general description of the tree, which included: inventory number, species name, and general metric data, i.e., trunk circumference at 1.3 m, trunk diameter at 1 m, bark thickness, total height of the tree, range of the tree crown, height of the base of the crown, height of the entire crown, as well as the approximate age, GPS coordinates, and health condition of the assessed tree with comments.

The overall health of the root system, trunk, and crown was important for visual inspection. The visual examination included the characteristics of the trunk's surroundings, the shape of the root neck, and changes and possible damage to the roots. The condition of the trunk essentially determines the health of the entire tree. In the case of fungal infections, the condition of the wood deteriorates, limiting the transport of nutrients and water. During the visual inspection of the trunk, we also considered the base of the crown, in terms of the way the branch fixing might affect the tree's static strength in the future. Assessing a tree's vitality also depends on the amount of downy growth, branch damage, crown asymmetry, or parasitic organisms such as fungi or mistletoe. To determine the vitality of the trees, it was also essential to assess the mechanical, physical, and biological damage (cavities, hollows, and sprouts; signs of insect feeding, fungal fruiting bodies, or exudates). We also paid attention to the leaning of the trunk and other external signs.

We examined trees from all sides, from roots to crown. Visual assessment is always qualitative and sometimes subject to errors depending on the assessor's experience, which should be considered when interpreting the results [18–20]. Of the 15 trees examined, we classified 10 as healthy with no visible damage. The remaining 5 specimens showed noticeable weakness (excessive branch drift, diminished leaves, and falling bark). Three specimens were subjected to detailed acoustic tomography examination for final confirmation of their health status.

We performed tree measurements using a measuring tape and mechanical caliper. The circumference of the trunks was measured using a measuring tape with an accuracy of 1 cm at 130 cm above the ground and the diameter was measured using the caliper at 100 cm above the ground. We measured the crown's reach using the Leica DISTO D5 rangefinder in two directions, N–S and E–W, and we averaged the obtained results. The height of the tree was measured using a Nikon Forestry Pro laser rangefinder. We performed photographic documentation using a NIKON D5300 camera. We also used specialized diagnostic equipment, such as the PiCUS 3 acoustic tomograph by Argus-Electronic GmbH.

The ages of the trees were estimated using several methods: age tables by Majdecki (1980–86) [21], age tables by Mydłowska (2014) [22], a tree age calculator [http://www.tree-guide.com/tree-age-calculator, accessed on 11 April 2023] [23], and a tree size guide [https://wdvta.org.uk/veteran_trees.php, accessed on 11 April 2023] [24]. The additional file contains Majdecki's and Mydłowska's age tables. Significant deviations between methods are often visible when assessing the age of trees. However, there are no better non-invasive methods for determining the age of trees. A more accurate assessment of the age of standing trees can be made using a Pressler probe or a resistograph. However, these are invasive methods. It is worth noting that, in addition to differences in the calculation methodology, the result may be affected by many factors (environmental conditions, substrate abundance, soil moisture, growth rate, or genetic factors); therefore, plantings even from the same period may differ significantly in terms of measured age.

Based on the conducted dendrological inventory and literature review, we created a revalorization concept for the garden around the temple.

2.3. Measurements with the PICUS 3 Acoustic Tomograph

In recent years, the number of tools and methods used in tree surveys has steadily increased [25–27]. Non-destructive testing can be divided into global techniques (ultrasound waves, stress waves, and resonance) and local techniques (probing, coring, and drilling) [28]. Among the methods used here were mechanical acoustic waves [28–30] and several others [31–33]. Using modern examination techniques based on acoustic tomography gives promising results compared to basic visual assessments [34–36]. Qiu et al. developed a tomographic technique using mechanical waves (i.e., stress and acoustic waves) and electromagnetic waves (i.e., laser beams) to evaluate tree trunk defects. In their experimental work, they used the tomographic technique to inspect a tree trunk with an air hole fabricated at the centric position and air gaps made at 5–50 mm near the surface. The results indicated that the internal air hole and air gaps at 5–20 mm below the tree surface could be effectively detected and quantified. Compared to the results using conventional sonic tomography, the presented tomographic technique achieved more accurate and reliable detection of internal defects in tree systems, especially if the internal defects were close to the free surface (i.e., critical defects associated with bending failure) [37].

In addition to the accuracy of the results, the measurement time is also essential. The Balas team evaluated the time needed for measurement and proposed an optimal workflow in 2020 [38]. The results of their work suggested that the scanning of one average-difficulty tree by SoT and ERT resistance tomography took an average of approximately 52 min when one operator measured one scan and approx. 37 min when two operators measured a queue of trees. Working in a two-person team was moderately more efficient. Typically, the overall cost of one scan is approximately EUR 25–30, depending on many variables.

Sonic tomography is a technique broadly applied for detecting defects and voids within several kinds of elements. Sonic pulse velocity tests (SPV tests) are widely applied for detecting the morphology, hidden defects, and voids within structural elements. This technique, broadly applied because it is non-invasive and easy to perform, is remarkably adaptable to ancient buildings, in which no damage is tolerated due to historic preservation requirements. Moreover, SPV tests were recently applied with tomography technology to obtain images of sonic speeds from which it was possible to rapidly reconstruct the morphology of the internal elements [39].

Camassa et al. (2019) proposed some improvements to ultrasonic tomography for masonry constructions, based on the implementation of advanced inversion algorithms, the use of information about wave attenuation (attenuation tomography), and acoustic wave time-of-flight measurements, and enhancements to the experimental setup concerning the coupling between probes and masonry [40].

The topographic measuring apparatus comprised a central unit, sensors deployed around the trunk, and specialized software (Figure 3). Before deploying the sensors, the trunk was tapped with a rubber mallet to pick up deafening noises, suggesting potential changes inside the trunk's internal structure. Only then was the correct measurement level established, and pins were placed around the trunk, at equal distances. Then, the pins were shallowly driven into the bark, on which the sensors receiving the acoustic waves were then attached.

Figure 3. Acoustic tomograph CT scanner on a tree trunk (photo by M. Dudkiewicz).

The number of sensors installed depended on the circumference and shape of the trunk mapped using a specialized PiCUS caliper (Figure 4).

Figure 4. Measuring the geometry of the tree trunk using the PiCUS caliper (photo by M. Dudkiewicz).

The first measurement point was always located on the north side to facilitate the interpretation of the results.

Acoustic tomography is based on measuring sound waves passing through the tree trunk between installed sensors. The sound waves are excited by tapping the individual sensors with an electronic hammer. The measurement process results in a color tomogram illustrating the sound velocity distribution over a trunk cross-section. The default color code for interpreting the results obtained using the included software is as follows: brown and black areas indicate high sound wave velocities corresponding to healthy wood; green corresponds to medium velocities, indicating a transition area between solid and nonsolid wood, but in some cases, it can also suggest problems inside the trunk; and purple, blue, and white areas indicate low sound velocities, characteristic of damage or voids inside the trunk. The processed sound velocity map (tomogram) can be used as a basis for making a scientific and knowledge-based decision on the viability of a tree without felling it. Yellow lines on the cross-section of the trunk suggest the occurrence of internal cracks, which often do not give apparent external symptoms. The thicker the line, the greater the risk of such an occurrence. In contrast, a red line on the tomogram indicates the limiting wall thickness, which allows the determination of the minimum mechanical strength of the tree trunk [41].

3. Results

3.1. Historical Outline of the Village

The founders of the village, the name of which is derived from 'chworost', meaning overgrown wilderness, were royal starosts in the early 16th century. Fr. Ivan Sopoćko, the Orthodox dean of Wlodawa and Brest, wrote in 1521 in his chronicle: "Okromie togo podaju kaplicu w siele Khorostyta, siemuż otcu Ignatiju Siergiewiczu fundacji ich miłosti panov Koptiow. Pri niejże i wołok dwa gruntu nadleżaszczich do tojże kaplica chramu założenija Czesnego Kresta." The temple's founder was a courtier of Sigismund the Old, Mikhail Vasilevich Kopeć, a hospodar marshal, advisor, and spokesman for Ruthenian affairs in the chancellery of the Grand Duchy of Lithuania. The first historical mention of an independent Horostytsya parish dates back to 1699. In 1702, the owners of the Opole estate, the Kopci family, founded a wooden, single-domed Orthodox church. In 1756, they sold the estate and Horostyta to Józef Sierakowski. Toward the end of the 18th century, the chamberlain of Lusk, Józef Szlubowski, a Sejm member, acquired the estate in 1790. In 1793–1794, the temple underwent extensive renovation, the presbytery was rebuilt, and another general renovation was carried out in 1848. In 1861, a wooden bell tower was erected, which survived. Another estate owner in Horostyta was Bronisław Deskur, a local heir who led the January Uprising in Podlasie. In the Horostyta Orthodox church, insurgents under his command swore allegiance to Poland. In 1875, the Orthodox Diocese of Chełm incorporated the parish, and from then on, it belonged to the second district of the Włodawa deanery. In 1915–1917, the clergy did not use the temple. At the beginning of 1923, a formal decision was made to reopen the church in Horostyta. According to estimates, the parish then had more than 5000 believers. Horostyta was a Ukrainian ukaz village, meaning the Tsar exempted the residents from serfdom by granting them land for ownership. However, the population faced various adversities, including as many as three displacement actions. The first of these was the great evacuation in 1915, known as the bieżeńżeń, the second was the displacement in 1945 deep into eastern Ukraine, and the third was during Operation Vistula in 1947, when the inhabitants of Horosyta were mostly deported and the parish was liquidated. In the 1960s, the population partially returned and regained their lands. The parish in Horostyta was reactivated in 1953 and incorporated into the Lublin deanery. By the end of the 1970s, the community had 360 believers; today, there are approximately 150 [42–44].

3.2. Symbolism in Orthodox Church Architecture

The founders of the village, the name of which is derived from 'chworost', meaning overgrown wilderness, were royal starosts in the early 16th century. Fr. Ivan Sopoćko, the Orthodox dean of Wlodawa and Brest, wrote in 1521 in his chronicle: "Okromie togo podaju kaplicu w siele Khorostyta, siemuż otcu Ignatiju Siergiewiczu fundacji ich miłosti panov Koptiow. Pri niejże i wołok dwa gruntu nadleżaszczich do tojże kaplica chramu założenija Czesnego Kresta." The temple's founder was a courtier of Sigismund the Old, Mikhail Vasilevich Kopeć, a hospodar marshal, advisor, and spokesman for Ruthenian affairs in the chancellery of the Grand Duchy of Lithuania. The first historical mention of an independent Horostytsya parish dates back to 1699. In 1702, the owners of the Opole estate, the Kopci family, founded a wooden, single-domed Orthodox church. In 1756, they sold the estate and Horostyta to Józef Sierakowski. Toward the end of the 18th century, the chamberlain of Lusk, Józef Szlubowski, a Sejm member, acquired the estate in 1790. In 1793–1794, the temple underwent extensive renovation, the presbytery was rebuilt, and another general renovation was carried out in 1848. In 1861, a wooden bell tower was erected, which survived. Another estate owner in Horostyta was Bronisław Deskur, a local heir who led the January Uprising in Podlasie. In the Horostyta Orthodox church, insurgents under his command swore allegiance to Poland. In 1875, the Orthodox Diocese of Chełm incorporated the parish, and from then on, it belonged to the second district of the Włodawa deanery. In 1915–1917, the clergy did not use the temple. At the beginning of 1923, a formal decision was made to reopen the church in Horostyta. According to estimates, the parish then had more than five thousand believers. Horostyta was a Ukrainian ukaz village, meaning the Tsar exempted the residents from serfdom by granting them land for ownership. However, the population faced various adversities, including as many as three displacement actions. The first of these was the great evacuation in 1915, known as the bieżeńżeń, and the second was the displacement in 1945 deep into eastern Ukraine, and the third was during Operation Vistula in 1947, when the inhabitants of Horosyta were mostly deported and the parish was liquidated. In the 1960s, the population partially returned and regained their lands. The parish in Horostyta was reactivated in 1953 and incorporated into the Lublin deanery. By the end of the 1970s, the community had 360 believers; today, there are approximately 150 [42–44].

3.3. Architectural Description of the Building

The church in Horostyta is oriented with the apse and altar facing east, and the entrance is in the opposite western wall. It is built of wood with a log structure on foundations, planked outside and inside, and reinforced with foxholes (Figures 5 and 6). On a rectangular plan, the nave has a newer babiniec added to the west and a slightly narrower, short chancel to the east. Adjoining the chancel to the north and south are rectangular, lower annexes housing the sacristy and treasury. The interior, once tripartite, is now a hall, with a newer music choir in the western part. The windows are rectangular, with semicircular closed windows in the chancel and transverse windows in the sacristy and treasury. The nave is accessed from the north by a stave door with a diamond studded pattern. The roof over the body was once tripartite, with a cupola over the central part. Today, it is five-pitched, shared by the nave and chancel, ending at the bottom with wide eaves with a lambrequin. The side slopes of the roof extend over the sacristy and vault. However, an onion-shaped signature tower rises in the middle of the ridge. Above the granary, the roof has a gabled form. All roofs are covered with shingles [45,46].

Figure 5. View of the church from the side of the municipal road (by M. Dudkiewicz).

Figure 6. Orthodox church in Horostyta—south elevation (by M. Dudkiewicz).

In the center of the church is a late-classical, wooden, blue-painted iconostasis from 1880 (Figures 7 and 8). It is single-story and has seven axes, with bronze pilasters decorated with rosettes, and it is enclosed by a cornice. Above the cornice is a finial with three paintings in finely decorated frames. Above the side, the volutes have crosses, while above the central volutes, the volutes are open. The culmination is gilded in bronze, and the fragments are painted blue. The openwork tsarist gates are formed of volutes and acanthus leaves, with crosses and rays. The iconostasis features contemporary icons of St. Nicholas, the Virgin and Child, Archangel Michael, Christ Pantocrator, the Exaltation of the Holy Cross, the Last Supper, the Shepherds' Bow, and the Ascension in the culmination. Representations of the Evangelists and the Annunciation are painted on Tsar's gates. At the iconostasis are two side altars from the first half of the 17th century, with paintings from the old iconostasis painted on boards. On the left altarpiece is the Mother of God and Child, and on the right is the patronal icon of the Exaltation of the Holy Cross (16th/17th century). Surrounding it, nine small scenes of the history of the Holy Cross are visible: Crucifixion, Baptism of St. Paul, Original Sin, Prayer of St. Paul, Empress Helena inquiring about the Holy Cross, Finding of the Holy Cross, Miracle of Resurrection through the Holy Cross, Building of the temple on the site of finding the Holy Cross, and Resurrection [42,43].

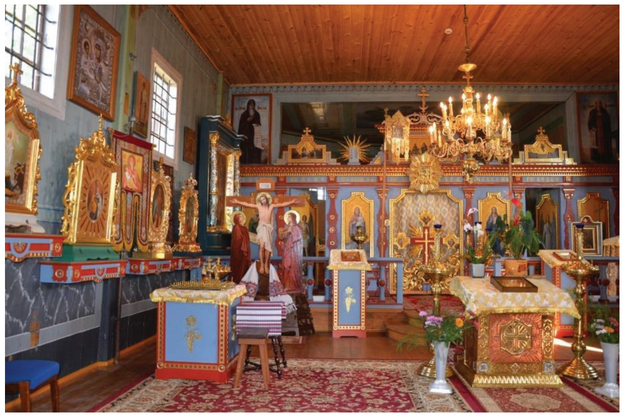


Figure 7. Orthodox church in Horostyta—iconostasis (by M. Dudkiewicz).

Figure 8. Orthodox church in Horostyta—elements of the interior (by M. Dudkiewicz).

A wooden two-story belfry, with a square plan of log-and-post construction planked and on a foundation, is located next to the church (Figure 9). Its lower tier is wider, separated by a slanting shingle roof, and the upper tier is narrower, with rectangular slits. The roof is tent-shaped and covered with shingles with a cupola on top [42,43].

In 2006–2007, the Orthodox church and belfry underwent a significant renovation, during which the foundations, damaged walls and roof structural elements, exterior formwork, floors, roof sheathing, windows, and door woodwork were replaced and the iconostasis was restored.

Since 2007, the Orthodox parish in Horostyta has been located on the Horostyta–Hola–Sosnowica–Dratów tourist route, "in the footsteps of the East Slavic Orthodox church tradition in Polesie Lubelskie."

Figure 9. Wooden belfry next to two sycamore maples (by M. Dudkiewicz).

3.4. Results of Detailed Dendrological Inventory

We inventoried 15 trees in the church garden, among which two species dominated: *Acer pseudoplatanus* and *Tilia cordata* (Table 1). Additionally, there are two trees with significant trunk circumferences, registered in 1992 as natural monuments: a small-leaved linden (672 cm in circumference) and sycamore maple (370 cm in circumference).

Table 1. Species and quantity lists of trees around the church in Horostyta, 2020 (authors).

No.	Latin Name	English Name	Number of Trees
1.	*Acer platanoides* L.	Norway maple	2
2.	*Acer pseudoplatanus* L.	sycamore maple	6
3.	*Tilia cordata* Mill.	small-leaved linden	6
4.	*Quercus robur* L.	pedunculate oak	1
			15

The Result of the Tomograph Examination

The fall of an entire tree or branch can cause significant damage to public infrastructure, personal property, and even human life [47]. Sometimes strong winds can also significantly affect the stability of a tree [48]. Aerodynamic drag on all surfaces of aboveground parts of trees—from individual leaves to entire tree crowns—significantly disrupts the airflow inside them [49,50]. The wind load affects the tree crown and generates significant bending moments on the trunk and its root. These are the primary sources of trunk damage and causes of uprooting. At the same time, it is worth noting that when branches move in the wind, they dissipate their energy, reducing the load transferred to the trunk and increasing the tree's mechanical stability. These features can be considered to be self-optimizing tree structures from evolutionary processes [51].

Safety in historic gardens with large trees is critical, and their preservation requires precise diagnostic techniques to detect structural damage to tree trunks caused, for example, by biological or physical factors. Visual tree assessment (VTA) is still the starting point for such studies. However, internal defects in tree trunks often remain out of sight of the arborist or botanist [52,53]. For many years, the Pressler auger was the only tool available for detailed assessment of the internal wood structure of a growing tree. However, this method requires mechanical intervention in the internal tissues of the tree. Its application in the case of valuable historic trees is controversial. At the beginning of the 21st century, surveys of the health of urban stands were conducted using various survey methods (electrical tomography, acoustic, etc.) with varying degrees of success. Of the methods used, acoustic tomography proved to be the most effective tool for detecting the distribution of internal tissues, being the most accurate in locating anomalies and estimating their dimensions and shapes and being the least invasive [54,55]. Compared to other methods, examination by acoustic waves is efficient even in the early stages of wood decay [56,57]. Gilbert and Smiley (2004) estimated that the average accuracy of the device was 89% [29]. Rapidly preventing the degradation of a protected specimen and properly conducting arboricultural work to keep the tree in good condition contribute to preserving the rich biodiversity of parks and gardens.

Additionally, it should be clarified that tree decay is a normal process, not an illness, and belongs to a tree's life, and that there should be decaying parts in old trees. Decaying wood is an essential part of an old tree and it supports other species and biodiversity. Decay is not always a risk, and a professional must conclude by looking carefully at the structure based on VTA and studying the decay using non-invasive methods or microdrill resistance whether structural weaknesses exist and what to do about them.

Many factors can cause decay in trees. Here are some of them: *humidity*—humid conditions support the activity of fungi and bacteria that promote tooth decay. Trees located in places with high humidity, e.g., by a riverbank or pond, are more susceptible to decay; *mechanical damage*—mechanical wounds on tree trunks or branches are places where microorganisms can penetrate; *lack of ventilation and light*—trees that grow in too much density do not have enough light.

Disturbing features and grounds for thoroughly examining a given specimen include peeling bark, holes, cavities in the trunk or branches, dead branches, and mushroom fruiting bodies (Figure 10).

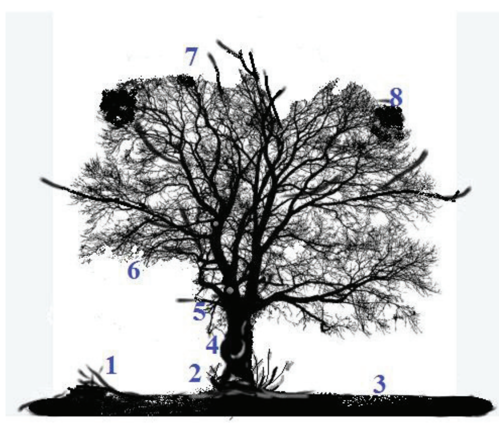


Figure 10. Senile tree. Designations: 1. dry branches under the tree; 2. suckers around the tree's crown; 3. early leaf fall; 4. bumps and mushrooms on the trunk; 5. hollow; 6. asymmetric crown; 7. broken top; 8. mistletoe.

The first thing an arborist may do is use a mallet to strike a tree's trunk and listen to the quality of the sound it makes. The sound of solid or decayed wood that has lost its structural strength sounds different. Next, an arborist may probe cavities with a metal rod to test how easily the cavity's interior gives way when pushed. Sound wood is hard and unyielding when poked, while decaying wood crumbles or allows a tool to pierce it.

We classified 12 of the 15 trees growing around the church as healthy due to the lack of visible damage. The remaining three specimens showed weakness (downy, small leaves, and falling bark). We examined the trees using acoustic tomography (Table 2). Signs of progressive decay were found inside their trunks, qualifying them for detailed observation for the time being but not immediate felling. This decision would depend on the wood's decay rate and the safety of the environment.

Table 2. Results of dendrological expertise (by authors).

No.	Species Name	GPS	Solid Wood	Temporary Wood	Damaged Wood	Conclusions from the VTA	Recommendation
1	small-leaved linden (*Tilia cordata* Mill.)	51°35′23.31″ N 23°14′16.27″ E	82%	11%	7%	suckers at the base of the trunk, dry branches, wilting leaves.	cutting and monitoring, marking the tree with tape, obtain information about possible danger.
2	sycamore maple (*Acer pseudoplatanus* L.)	51°35′23.35″ N 23°14′17.43″ E	62%	7%	31%	tilted tree, many hollows in the trunk, visible decay.	cutting and monitoring, marking the tree with tape, obtain information about possible danger.
3	small-leaved linden (*Tilia cordata* Mill.)	51°35′24.38″ N 23°14′16.83″ E	53%	19%	28%	significant deadwood in the crown, peeling bark, traces of insect feeding in the trunk.	cutting and monitoring, marking the tree with tape, obtain information about possible danger, reconstruction of the foundation of the fence.

Object 1—small-leaved linden (*Tilia cordata* Mill.)

The assessed tree grew on a slight elevation at a distance of 1.5 m from the fence separating the church from the cemetery. The distance from the walls of the church building was 14 m, and it was 1 m from the neighboring tree (Figure 11). In the tree's crown, the growth of small downy branches was estimated at 20%, with hanging branches and wilting leaves. Traces of the maintenance work carried out were visible, and the areas of cuts were well healed. Based on the tomographic results obtained, small foci characterized by weakened internal wood structures were estimated at 8%, located on the northern side of the trunk section. They did not significantly affect the mechanical strength of the trunk. Technically sound wood occupied 85% of the trunk cross-section, and the remaining part (7%) was so-called transitional wood with a slightly weakened structure but was not yet damaged. The recorded speed of sound inside the trunk ranged from 817 to 1150 m s^{-1}, which suggested the tree was in good condition, especially since, according to the available literature, the average speed of sound waves in healthy linden wood is in the range between 940 and 1183 m s^{-1} [58].

The red line illustrated the minimum wall thickness of 12.8 to 13.6 cm (average 13.2 cm), depending on the site, which indicated that the safety limit against trunk fracture was preserved on most of the cross-section. Destructive processes only went beyond this limit on the north side of the trunk.

Calculated for different directions, the trunk section's geometric moment of inertia, measured at the weakest point at the measurement height, ranged from 3.2% to 7.8% of the maximum strength relative to a trunk without defects or damage. The calculations themselves only took into account the trunk's geometry at the measurement level, while the properties of the wood itself may affect the final result of the measurement. Based on the results obtained, one could assume that the tree's mechanical strength and resistance to trunk bending were safe for the environment (Figure 12).

The minimum thickness of a healthy wall relevant to the preservation of tree statics, calculated by the Tree SA method, should be 6.6 cm on average (green line on the attached tomogram). Based on the measurement carried out at the height of 120 cm above ground level, we found that significant weakening of the wood structure occurred only at the height of the 1st and 2nd measurement points in the northern part of the trunk section, and the safety limit was still preserved.

As calculated by the Tree SA method, the wood in the solid trunk required a minimum residual strength of 38%. However, based on the tomographic survey, the percentage of entirely sound wood was 85%. This finding testified to the good statics of the tree (Figure 12).

According to the Roloff scale, the evaluated linden was in the exploration stage (grade 0) [59].

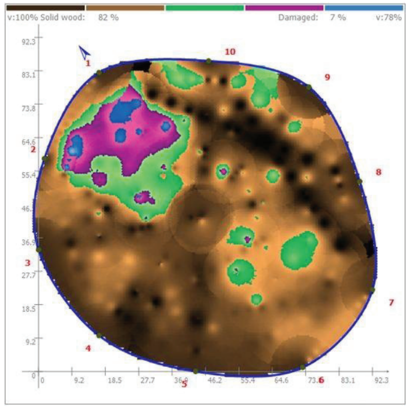
The tree grew very close to another tree, which may have resulted in insufficient sunlight. On the trunk and branches, there were traces of maintenance cuts that may have allowed the penetration of fungi that weakened the tree. The wilting leaves were also evidence of a slight weakening of the plant's vitality.

The project suggested leaving the tree and its surroundings unchanged, i.e., as lawn turf. Planting a floor of shrubs around the trunk or locating small architectural objects under the tree canopy were not planned. The project recommended removing dead branches, and that all work and care procedures should be performed following the rules of arboriculture by a team qualified to care for veteran trees. The condition of the tree should be monitored every 2 years.

Figure 11. General view of small-leaved linden (by M. Dudkiewicz, 2020).

Object 2—sycamore maple (*Acer pseudoplatanus* L.)

The tree grew 0.3 m from the fence wall in the eastern part of the property (Figure 13). The trunk had several cavities, mainly hollows of various sizes. The initially straight trunk from a height of 2.5 m sloped northward at an angle of 30° and revealed several breakages in the crown, resulting in hollows and branch ashes at a level of 15–20%. The topographic examination showed progressive destruction of the trunk's interior in the core, moving to the outer layers on the northeast side at the height of measuring points 7–8. At this point, the minimum wall thickness required to maintain the proper mechanical strength of the trunk, which should have an average thickness of 10.6 cm, was also not maintained. The recorded speed of sound traveling in the wood of the tested maple ranged from 818 m s^{-1} between measurement points 7 and 2 to 1616 m s^{-1} between sensors 4 and 3. Referring to the average speed of sound waves propagating in healthy maple wood, which is on average from 1006 to 1426 m s^{-1} [58], one could conclude that the lower recorded value was slightly lower than the norm while the other was well above the accepted level.



Trunk circumference at the height of 1.3 m: 293cm
Height: 17 m
Crown range: 11.5 m
Approximate age: 121years, 121years, 202years, 97years

Instructions:
1. Tree to keep.
2. Dry branches should be removed following the rules of arboriculture by a team qualified to care for veteran trees.
3. Health monitoring every 2 years.

Figure 12. Tomogram of the interior of small-leaved linden trunk inv. no. 4 (by W. Durlak) [21–24].

Damaged wood on the cross-section of the trunk occupied 30% of the area, and healthy wood occupied 62%. The remaining area was transitional wood (Figure 14). It was most likely that the destructive processes that had begun would worsen in the future. Therefore, monitoring the tree was recommended for the time being in order to prevent possible felling.

The minimum wall thickness indicated by the red line on the tomogram, considered the safety limit before stem fracture, was between 9 and 12.1 cm (average 10.6 cm), depending on the site. It was preserved in most of the cross-section. Destructive processes only went beyond this limit on the northeast side of the trunk (Figure 14).

Calculated for different directions, the geometric moment of inertia for this section of the trunk, measured at the weakest points at the height of the measurement, ranged from 51.3% to 56.7% of the maximum strength compared to a trunk without defects or damage. Based on the results, one could assume that the tree's mechanical strength and resistance to trunk bending were safe for the environment.

The minimum thickness of a healthy wall relevant to the preservation of tree statics, calculated by the Tree SA method, should be 7.15 cm on average (green line on the attached tomogram). Based on the measurement carried out at 80 cm above ground level, significant weakening of the wood structure occurred only in a small area around the 8th measurement point in the northeastern part of the trunk section. In the remaining area, the safety limit was preserved in excess.

As calculated by the Tree SA method, the required minimum residual strength of the solid wood of the trunk of this tree was 48%. On the other hand, based on the tomographic survey, the percentage of utterly sound wood was 62%, which confirmed the good statics of the tree.

According to the Roloff scale, the evaluated linden was in the exploration stage—light degeneration (grade 0–1) [59].

The tree grew close to another tree and right next to a brick fence, which may have resulted in insufficient sunlight. There were hollows in the trunk, broken branches, and deadwood in the crown. The tree's strength was probably weakened by the low amount of light and humid conditions in which the tree grew (by the old brick fence), which resulted in the decay of the trunk.

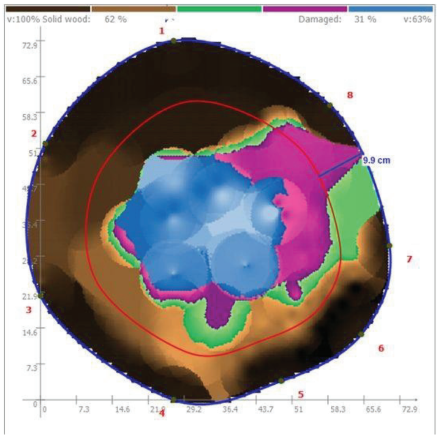
The project suggested planting low turf vegetation around the tree. Locating small architectural objects under the tree crown was not planned. The project suggested removing the dead branches, and that all work and care procedures should be performed following the rules of arboriculture by a team qualified to care for veteran trees. The condition of the tree should be monitored every 2 years.

From the south, a hollow at the height of 0.8 m reaching deep inside the trunk Ø 0.1 m. The second hollow - smaller, at a height of 1.5 m from the south, measuring 0.1×0.02 m. From the west, at the height of 2.8 m, a hollow, probably from a broken branch measuring 0.3×0.15 m. Trunk initially straight up to 2.5 m and then sloping toward the north at an angle of 30°.

Figure 13. General view of sycamore maple (by M. Dudkiewicz, 2020).

Object 3—small-leafed linden (*Tilia cordata* Mill.)

A small-leaved linden grew near the main gate on the northern side of the church (Figure 15). It was characterized by its considerable size and quite downy solid growth in the upper parts of the crown. The crown showed traces of broken branches, and the surgical cuts were partially healed. Numerous heavily leafy outgrowths appeared on the trunk. The crown was asymmetrical, facing north. At the base of the trunk, large root intakes had developed. Traces of insect activity were also visible. The upper part of the tree trunk had numerous hollows. The root system was strongly developed, pushing slightly against the fence's foundation. The CT scan made it possible to determine the health of the trunk's interior (Figure 16). Linden trees are characterized by wood susceptible to biocorrosion; hence, the destruction visible on the tomogram in the core part of the trunk was a common phenomenon. We calculated the limiting wall thickness considered safe for this trunk's mechanical strength to be 16.9 cm on average.



Trunk circumference at the height of 1.3 m: 232 cm
Height: 17 m
Crown range: 18 m
Approximate age: 132years, 132years, 133years, 62 years

Instructions:
1. Tree to keep.
2. Dead branches to be removed. All work and care procedures should follow the rules of arboriculture by a team qualified to care for veteran trees.
3. Health monitoring every 2 years

Figure 14. Tomogram of the interior of sycamore maple inv. no. 11 (by W. Durlak) [21–24].

The recorded speed of the sound wave in the wood of the evaluated linden ranged from 320 m s^{-1} between measurement points 8 and 2 to 1245 m s^{-1} between sensors 4 and 12. The recorded value was much lower than the average, influenced by the movement of sound through the damaged areas slowing down its speed. The upper value, on the other hand, was within the norm and even slightly exceeded it.

Damaged wood occupied an area equal to 26% of the cross-sectional area of the trunk, while healthy wood occupied 56%. The remaining 18% was transitional wood (Figure 16). Most likely, the destructive processes that had begun would worsen in the future, but it was unknown at what rate. Therefore, it was worth monitoring the tree and holding off on possible felling.

The minimum wall thickness marked on the tomogram with a red line, considered the safety limit against trunk fracture, was 16 to 17.8 cm (average 16.9 cm), depending on the location. This limit was preserved practically throughout the cross-section, indicating that the trunk's mechanical strength was still good.

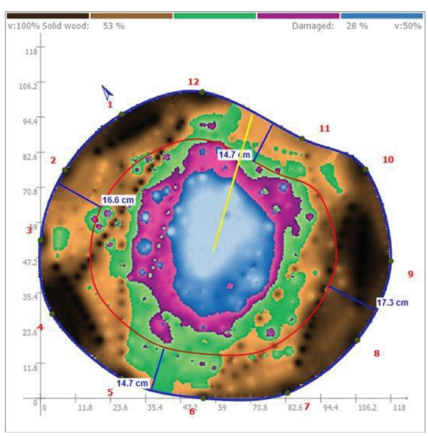
The attached tomogram also shows two yellow lines indicating the possibility of internal cracks, the most likely one oriented to the northeast between measurement points 11 and 12.

Calculated for different directions, the geometric moment of inertia for this section of the trunk, measured at the weakest points at the height of the measurement, was 10.8% to 48.9% of the maximum strength compared to a trunk without defects or damage. Based on the results obtained, one could assume that the tree's mechanical strength and resistance to trunk bending were safe for the environment.

The minimum thickness of a healthy wall relevant to the preservation of tree statics, calculated by the Tree SA method, should average 5.8 cm (green line on the attached tomogram). Based on the measurement carried out at 130 cm above ground level, there was no significant weakening of the wood structure at this trunk section. The required safety limit was maintained in excess.

Numerous broken branches. Large stature in the crown. Crown facing north. Large rooting and regrowth on the trunk. Thick branch cut from the south, as well as from the north and east sides. Roots are pushing the fence foundation outward. Visible hollows in the upper part of the trunk on the north side. Falling bark. Traces of insect feeding in the trunk (exit holes). Nodular growths - remnants of branches - at different heights on each trunk side.

Figure 15. General view of small-leaved linden growing at the entrance of the property (by M. Dudkiewicz, 2020).



Trunk circumference at the height of 1.3 m: 367 cm

Height: 17.8 m

Crown range: 10 m

Approximate age: 152years, 152years, 252years, 123years

Instructions:

1. Tree to keep.
2. Dead branches to be removed. All work and care procedures should follow the rules of arboriculture by a team qualified to care for veteran trees.
3. Modifying the foundation of the fence to allow root growth.
4. Health monitoring every year.

Figure 16. Tomogram of the interior of small-leaved linden inv. No. 15 (by W. Durlak) [21–24].

As calculated by the Tree SA method, the required minimum residual strength of the solid wood of the trunk of this tree was 23%. On the other hand, based on the tomographic survey, the percentage of entirely fine wood was 56%, which indicated good tree statics (Figure 16).

According to the Roloff scale, the evaluated linden was in a borderline stage between degeneration and stagnation (grade 1–2) [59].

The visual condition of the tree was disturbing. Traces of insect activity were visible on the trunk, and the crown was asymmetrical. There was a large dead branch, and the tree put out many root suckers. Modifying the fence's foundation was planned to allow root growth. The tree probably used to grow in a row of trees, and now it was a single object exposed to the wind. It was planned to plant two small trees on both sides of the linden. The project recommended removing the dead branches, and that all work and care procedures should be performed following the rules of arboriculture by a team qualified to care for veteran trees. The condition of the tree should be monitored every year.

The temple walls were shrub beds composed of, among other plants, *Juniperus chinensis* 'Stricta', *Thuja* 'Smaragd', *Spirea japonica*, and *Physocarpus opulifolius*. The selection of species primarily included species of foreign origin and characteristics mainly of home gardens rather than religious establishments. There was no reference to the plant symbolism crucial to the Christian faith.

4. The Problem of Protection of Senile Trees

Old trees are witnesses to history [60,61]. They are not only picturesque elements of the cultural landscape (often painted, photographed, and described) but also a vital part of the natural world. They are the habitat of rich biological and microbial life. According to British data, more than 2000 species of invertebrates (6% of British invertebrate fauna) depend on the habitat of senile trees; therefore, removing such tree canopies seriously affects the biodiversity of cities and villages [62]. Dendroflora is also an essential biodiversity refuge with sometimes rich associated flora. Many species of lichens live on tree trunks, including rare and protected species. Branches are convenient places for bird nesting, and many species of birds (including legally protected birds) live in treetops, such as nightingales, nightjars, blackbirds, grackles, and kestrels.

Dangerous trees pose a significant risk to landowners and those who care for them. It is worth mentioning in this context that the ISA (International Society of Arboriculture) has created a so-called qualification to define the risk assessment of trees (Tree Risk Assessment Qualification—TRAQ). This qualification promotes people's and property's safety by providing a standardized and systematic process for assessing tree risks. The results can provide tree owners and risk managers with information to help them make informed decisions to increase the benefits, health, and longevity of trees [63].

Tree dieback begins with crown thinning, yellowing, and other symptoms on the leaves, a morbid appearance, and the top drying out. Tree branches begin to die from top to bottom. External features include spiral rings in the tree trunk, thin or balding bark, loss of apical dominance, crown dieback, and crowns with few large branches [64]. Pederson described six typical external features of old angiosperm trees. These features include: (1) smooth-textured bark; (2) a reduction in the tree's growth strength; (3) high waviness of shoots; (4) crowns composed of few, thick, and twisted branches; (5) low crown volume; and (6) a low ratio of leaf area to trunk volume [60].

Here, it is worth noting that tree death is a normal process, not a disease, and is part of the tree's life cycle. Decay is one of the crucial processes in old trees and decaying wood supports other species and biodiversity. Decay itself is not always a risk, and the professional must draw conclusions based on proper observations (VTA) and decay testing using non-invasive methods in order to assess whether there is structural weakness and what to do about it.

4.1. Threats Related to the Felling of Ancient Trees

An old-growth tree is a valuable element of tall greenery in urban and rural areas, and, despite its advanced age or significant damage, it is an invaluable element of biodiversity. Any overly hasty decision to remove an aged tree is a considerable loss to the environment, both image-wise, nature-wise, and often historically. In Poland, trees around historic churches are protected as greenery growing on a property entered in the register of monuments. Under this assumption, removing, destroying, or damaging a tree is a crime under Article 108 of the Monuments Act [65]. Unfortunately, we often witness illegal felling or improper care of senior trees (Figures 17–20). Most often, it is topping, i.e., removing the top part of the tree to slow down the growth of the tree, lower the center of gravity, or reduce the size of the crown. "Topping" leads to the destruction of the crown and is a mistake. Due to inefficient tree care, municipalities or parishes have to pay multi-million fines. We must sensitize society and the authorities (secular and ecclesiastical) so that the surroundings of churches are cared for and respected in order to preserve our cultural heritage and their natural value. This research is an example of how carefully each case of a veteran tree should be considered.

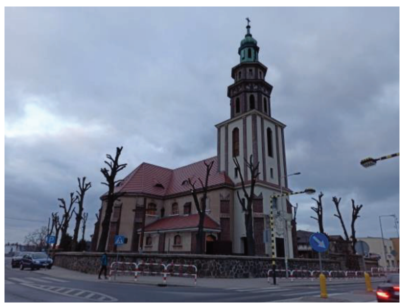


Figure 17. Destruction of trees around the Church of St. Marcin Wincenty in Skórzewo near Poznań (Greater Poland Voivodeship) (photo M. Dudkiewicz, 2022).

Figure 18. Destruction of trees around the Church of St. Marcin Wincenty in Skórzewo near Poznań (Greater Poland Voivodeship) (photo M. Dudkiewicz, 2022).

Figure 19. Destruction of trees around the church in Zajezierze near Dęblin (Lubelskie Voivodeship) (photo M. Dudkiewicz, 2022).

Figure 20. Destruction of trees around the church in Zajezierze near Dęblin (Lubelskie Voivodeship) (photo M. Dudkiewicz, 2022).

People hastily remove trees because of the perception of trees as a problem, e.g., threats to the church building. This is primarily due to low social awareness of the importance of trees for biodiversity and ignorance about the principles of their proper care and protection [66]. The fundamental importance of solving the presented problem was to improve the administration and management system of trees in cities, following the example of similarly operating structures in European countries and in America (Table 3). In Germany, urban tree control is a safety assessment, the form of which is defined in the Baumkontrollrichtlinie (Tree Control Policy). The German Association of Landscape Experts (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau) certifies tree care and assessment inspectors. The state registers street trees in a unified cadastral system, and trees over 40 years old are inspected twice a year for traffic hazards. Thanks to constant observation, we can assess how the tree copes with stress factors, whether it produces defense mechanisms, and how the observed defects and diseases progress. International institutions, such as the International Society of Arboriculture, also define standards.

Table 3. Ways of minimizing risk management related to ancient trees based on European and American programs.

Risk Prevention	Minimizing and Correcting Threats
1. Rational design of space around ancient trees. Shaping safe compositions (separating trees with shrubs and flowerbeds from sidewalks and benches) (Figure 21). 2. Proper care performed following the principles of arboriculture by a team qualified in the care of veteran trees. 3. Monitoring and objective assessment of trees in terms of safety hazards, allowing for making decisions about dealing with the tree. 4. Education of garden owners and users.	1. Making decisions adequate to the level of risk using minimal to advanced diagnostic methods, e.g., sonic tomography. 2. Closing the tree in the tree protection zone (crown range plus 1 m) from public traffic. 3. Fencing off the projection of the tree crown with string or tape. Placement of warning signs, e.g., bands on the trunk and signs on the lawn (Figures 22–24). 4. Cuts correcting the crown and improving the tree's statistics, using mechanical reinforcements. 5. Improvement of passage conditions, removal of the concrete surface around trees, replacement with air spades, mycorrhiza. 6. If the tree is next to a fence, adaptations of the foundations and fence (Figures 25 and 26).

4.2. Research Limitations in Acoustic Tomography for Senile Trees

It is also worth mentioning the research limitations, which included the sizes of the tree specimens under study. The distance between measuring points (electrodes) on the edges of the tree trunks under study was determined using the PiCUS electronic caliper. Unfortunately, the range of its arms was insufficient to examine trees with a considerable breast height. Therefore, determining the tree cross-section sometimes had to be performed by hand. After hitting the tree trunk with a hammer, an acoustic signal is generated in each electrode, the time is recorded, and the speed of passage of the acoustic waves between each sensor is calculated. In the case of a large internal cavity in a tree of considerable size, some readings were not very precise and required several harder hammer blows. The measurement set consisted of 12 sensors and an electronic device, and a large tree specimen required rearranging the sensors and taking an additional measurement at another 12 points, which increased the time needed for the survey.

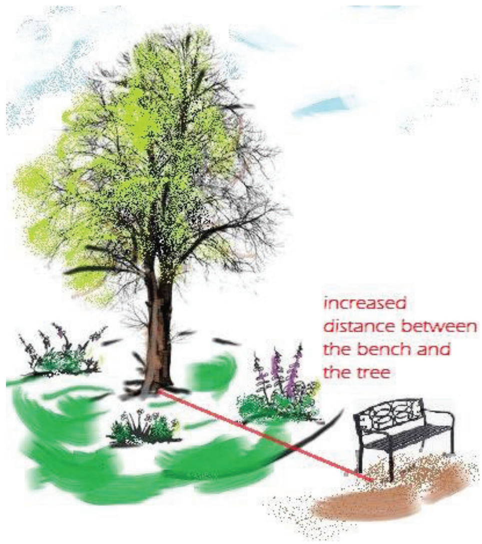


Figure 21. Senile tree in a historic garden—planted perennials can move traffic and benches are located beyond the projection of the tree crown (by M. Dudkiewicz).

Figure 22. Rubber band on the trunk with dendrometric data of the ancient tree and a request to be careful when parking under the tree crown, especially during a storm. Center for Contemporary Art Ujazdowski Castle in Warsaw (photo M. Dudkiewicz, 2022).

(**a**)

(**b**)

Figure 23. (**a**) Rubber band on the trunk with dendrometric data of the ancient tree. Center for Contemporary Art Ujazdowski Castle in Warsaw (photo M. Dudkiewicz, 2022). (**b**) Fencing off an ancient oak with a rope and placing signs warning about falling branches. Ujazdowski Park in Warsaw (photo M. Dudkiewicz, 2022).

Figure 24. A sign with the inscription: Area of an old stand. Danger of falling branches. Staying near old trees is associated with the risk of loss of life and health (photo M. Dudkiewicz, 2022).

Acoustic tomography also has other specific limitations. In some cases, the course of acoustic waves can be disturbed by the internal structure of the wood, such as reaction wood. Interpretation of the tomogram is also sometimes hampered by the presence of cracks or plugs, which tend to occupy a larger area on the tomogram than in reality. A particular case that makes it difficult to correctly read the information in the acoustic tomogram is the occurrence of so-called wet wood in some deciduous trees, mainly elm and poplar. The altered area in the central (core) part of the trunk is depicted on the tomogram in the same way as a cavity caused by rot, whereas the presence of wet wood in the trunk primarily makes the wood immune to rot fungi and has little effect on the stability of the tree. We can conclude that the device provides reliable information on wood density by determining the reason for the presence of low-density wood objects visible on the tomogram. The potential significance of these defects for tree stability and viability requires more profound dendrological knowledge [67].

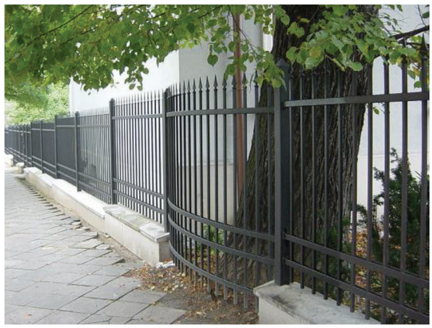


Figure 25. Planned lack of foundations to protect an ancient linden tree (photo M. Dudkiewicz, 2018).

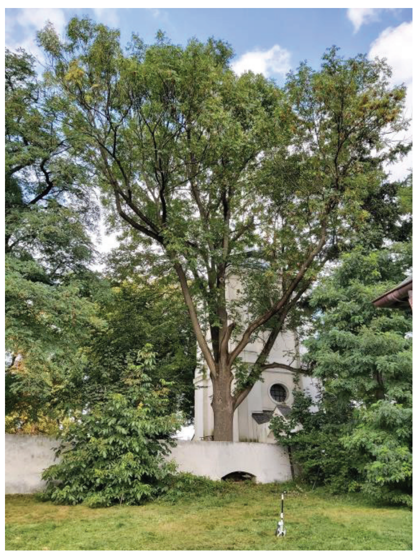


Figure 26. Planned cut-out in the wall to leave room for the development of ancient ash roots at St. Paul in Sandomierz (photo M. Dudkiewicz, 2020).

While advanced decay detection technologies are effective in quantifying internal decay, it is not clear how the additional information provided by these instruments impacts risk assessments concerning the likelihood of failure. Even the once commonly accepted arboricultural rule of thumb, $t/R > 0.3$–0.34 (where t is the radial thickness of sound wood, and R is the trunk radius; Mattheck and Breloer, 1994 [68], has not been spared from debate over its accuracy or widespread applicability [34,68].

5. Guidelines for the Design of Orthodox Gardens

The places where temples were built in the past were not accidental. Orthodox churches were located in places marked by a miracle, a revelation, and the fervent faith of the faithful. People harmoniously integrated the buildings into nature. Today, the surroundings of old churches are often the last refuge of centuries-old tall trees. Amid numerous modern landscape transformations, ancient churches surrounded by greenery remind us of our desire to preserve harmony with the world [69]. In villages, churches were mostly wooden and built in the highest place. If there was a river or lake nearby, then these were also included in the overall composition [70].

The church garden area is an intermediate zone between the sacred (the temple) and the profane (inhabited areas). Orthodox churches and their surroundings have also been burial sites for the faithful for centuries. It was not until the Edict of Nantes of 1777 that the burial of the dead near churches was banned for sanitary reasons. Following France's example, other countries, including Poland, introduced similar regulations. The effect of these changes was to transform the areas of former church cemeteries into landscaped areas, where votive crosses and rows of trees were located, forming a clear boundary in the landscape [71]. Its architectural enclosure gains a landscape dimension with a row of trees along the church's borders. Practical, aesthetic, and symbolic reasons dictated such a solution, thereby accentuating the separation of the sacred and profane zones. Deciduous tree canopies of lindens, oaks, ash, and chestnut trees usually surround temples [72].

In the Orthodox tradition, green is the color of spring and rebirth. In iconography, green is the herald of the Holy Spirit and the color of John the Evangelist and many prophets. Red symbolizes life, beauty, divine love, and power. However, at the same time, it also signifies martyrdom and blood. The color white in the Orthodox church symbolizes God's revelation and glory. White is also used to represent joy and a festive mood and symbolizes purity, innocence, God's wisdom, joy, and happiness. The color brown represents the material world, humility, and poverty [73,74].

Although this manuscript deals with a small rural Orthodox church, it is worth mentioning the basic principles of the spatial composition of an Orthodox monastic complex. Orthodox monastic gardens were characterized by the social and functional specialization of the garden, unity with the surrounding landscape, traditionalism and canonicity, symbolism, and rituals. The garden of the monastery complex was not limited to the inner part of the monastery walls. It was a multilevel system of greenery inside and around the monastery. The central garden, with a specific layout and planting structure, was located inside the monastery walls near the cathedral church. Smaller gardens were located near other buildings. Utility crops grew on the periphery of the monastery complex. By the 14th century in Russia, the concept had taken shape that only primordial nature was sinless, ordered by God Himself and in harmony with it. Monasteries were placed on hillsides, hilltops, and, if on flat terrain, in the bends of rivers, tributaries, or islands. Thus, the monastic complex was dominant in a given landscape within a radius of several miles. The low density of the monastery, high plantings in the monastery courtyard, and the use of native plant species "dissolved" the monastery into the environment, making it an organic part of the natural landscape. One of the main functions of the garden was to replicate the process of creating the world in miniature.

The entire monastery was conceived as "heaven revealed on earth." The placement of the monastery on a hill was seen as an approximation of heaven, God, and Eden. The axis of the main gate and the temple symbolized salvation. The main cathedral's centrality and dominance in space signified the "One God," the microcosm and heaven. Other buildings around the main cathedral embodied the Righteous around the throne of God [74].

An essential element in the composition of the church's surroundings was to allow a circular route around the main temple and to form a square in front of it. Additionally, the presence of an Orthodox cross was desired on each building, as well as small architectural forms, i.e., an '*istocznik*' spring and *phiale* (a place for water to shine), flower compositions by the main square, the use of white lilies and white flowers in the garden, and the presence of apple trees. If possible, an avenue of linden trees led to the church. The species selection of plants in gardens was made considering the plants' symbolism and their flowering period during the most important religious holidays. Thus, the Orthodox church garden was, in a sense, a metaphor that tells biblical stories and encourages concentration, prayer, and reflection [74].

Orthodox church garden rituals included processions and sanctification of gifts as a common prayer for God's protection, help, and glory. These included:

1. Grand processions—Velyki Khresni khody (Paschal Way of the Cross, Velyke Vodosvyachennya or Way of the Jordan);
2. Prestol'ni Khresni khody—the days of the patronal feasts of a particular monastery;
3. Church-wide rite of consecration of gifts and small processions around the cathedral (Apple Spas and Nutty Spas, Palm Sunday, Easter);
4. Episodic line processions at meetings of the higher clergy or holy icons in monasteries, monks' burial rank, and others.

All of the above rituals, therefore, required a square where people gathered during the ordination of gifts and a circular avenue around the church as a processional route, highlighting the main avenue leading from the gate to the temple, and side paths to the church cemetery, the '*istochnik*', and '*phiale*'.

In summary, in the case of evaluating the greenery system on the territory of a historic religious site, the basic principle of the development should refer to the historical species selection in such sites and plantings should follow the principles of religious symbolism [75–77]. The churchyard garden should be rich in symbolic colors while having a contemplative atmosphere. The designer should consider the patrons of the church and the iconographic program should also appear on the exterior of the building. Physical and spiritual relaxation, concentration, and reflection should be fostered by elements of small architecture, i.e., benches, and commemorative crosses that are adequately integrated into the entire garden establishment. It is worth using species and varieties of ornamental plants, shrubs, and trees with resinous fragrances or fragrant inflorescences (e.g., lindens, larches, pines, spruces, and roses). As Forstner (1990) notes, all of these stimuli, while stimulating the senses and deepening the scale of the experience, primarily point to something extraordinarily subtle and spiritual [78]. Thanks to the vegetation, the church's immediate and distant surroundings should form a spatial and ecological whole [72]. Trees are commonly used to plant the boundaries of church areas. Thanks to the row of trees along the church's borders, its architectural fencing gains a landscape dimension. Practical, aesthetic, and symbolic considerations dictate this solution, in that it emphasizes the separation of the sacred from the profane.

6. Design Concept of the Church Garden

Finding a balance between natural, historical, and user safety aspects is one of the most critical challenges in the sustainable management of garden monuments. Veteran trees should be provided with adequate living space. Sufficient light and space should reach the trunk and crown, and the extensive root system should have proper soil volume. In this way, the stand should continue to age slowly in peace while remaining in a favorable environment, if possible.

The presented design concept achieved a compromise between tradition and the modern user's needs (Figure 27). The project involved renovation of the fence, the installation of benches, lighting, and construction of a spring. We planted five new trees to supplement the planting in a row along the fence. The senile trees were some distance from the processional road. Flowerbeds surrounded them. This should improve the living conditions of the veteran trees and prevent people from walking under their crowns. We planted shade-loving perennials under the crowns of the trees. The curves of the flowerbeds referred to rural and naturalistic gardens. Considering the plantings used in the project, we suggested their symbolic meaning: periwinkle—fidelity, eternal life; ivy—the permanence of life; boxwood—hope of salvation, immortality; yew—immortality; syringa—kindness; lilac—zeal, diligence; tonsil—vigilance, youth, piety, diligence, new life; quince—marriage; peony—shame; rose—eternal wisdom, martyrdom, transience, mystery, eternity, marriage. In turn, we selected the proposed flower species based on their religious significance and specific symbolism: marigold—penance, abstinence; pansies—timidity of young girls, faithful memory, the Holy Trinity, faithfulness, envy; violet—love, humility, passing, modesty, a widow, a believer, the earth awakening to life after winter; carnation—love, boldness, kindness; iris—suffering, recklessness, the Passion of Christ, forgiveness of sins, sadness; lily of the valley—the salvation of the world; lily—purity, a soul striving for God, a faithful soul, virginity, royal dignity, transience, the word of God, light, spring; mallow—pain, mercy, request for forgiveness; forget-me-not—sincere love, faithful memory, naive simplicity; fern—modesty, daisy—eternal youth; tulip—goodness [79–81].

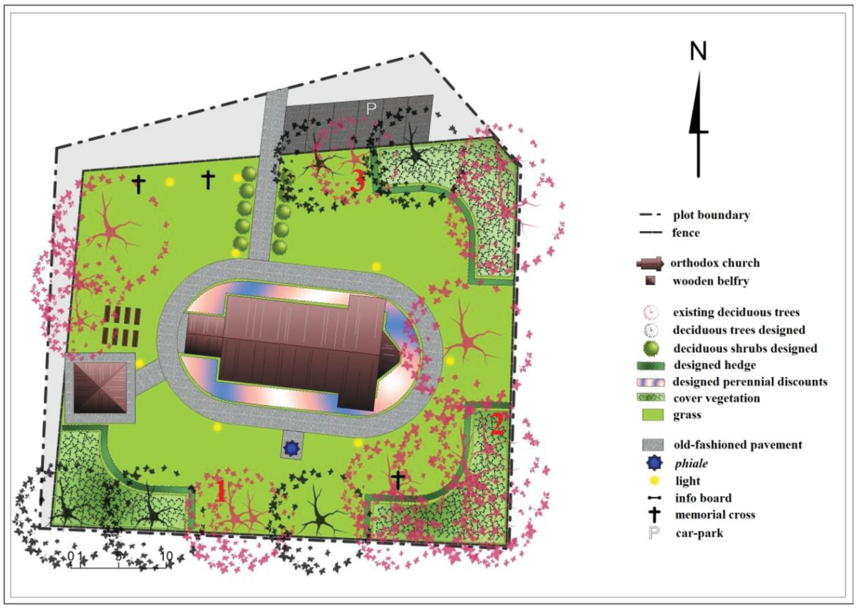


Figure 27. Project for the development of the surroundings around the church in Horostyta (by M. Dudkiewicz).

7. Conclusions

This manuscript presents a case study for the inventory and design of a garden at a historic Orthodox church in Horostyta, a village in southeastern Poland. In the church garden, we inventoried 15 trees, among which two species were predominant (*Acer pseudoplatanus* and *Tilia cordata*) and the most valuable ones were a small-leaved linden with a trunk circumference of 672 cm and a sycamore maple with a trunk circumference of 370 cm, which were about 200–300 years old. Plans to fell three trees with disturbing visual assessments were abandoned thanks to detailed acoustic tomography tests. The CT scans revealed some problems and signs of decay, but they did not indicate cutting.

The obtained results made it possible to design a garden adapted to the health conditions of the ancient trees—they were separated from users by flowerbeds, small architectural objects were not located around them, and their trunks were marked with tape informing users about the possible danger of falling branches.

The presented revalorization concept followed the principles of good conservation practice with the needs of contemporary users in mind. The solutions we applied emphasized the historical and aesthetic value of the whole.

At the moment, according to the recommendations, care work on the trees has already been carried out. Fundraising for the project is underway.

Old-growth trees, an integral part of historic establishments, increase the cultural and historical value of sites and maintain the proper compositional arrangement. Using precise computer techniques that make it possible to detect decay and other types of structural defects inside tree trunks ensures proper safety for people and property in the area where historic trees grow. The need for the above research stemmed from the demands of a Polish conservationist and the landscape architect community for new methods and tools to help shape the space. In this case, acoustic tomography revealed the health status of the interior of the trunks of three selected trees. By gaining a better understanding of the internal structure of the trunks, it was possible to more accurately determine the level of risk generated by and around the trees and then choose the best course of action. The information provided by acoustic tomography made it possible to avoid the felling of trees in favor of regular monitoring. The present study confirmed the validity of the chosen method and the apt choice of tools suitable for the study of sacred gardens.

The authors hope that this publication will fill a severe gap in knowledge about the latest available technology in conserving historic gardens. It was an essential and complicated task in which the needs of three parties—the property owner, the conservationist, and the users and tourists—had to be reconciled. It was interdisciplinary research in which we faced the vast area of diagnostics and arboriculture and the entire thematic and formal complexity of sacred gardens. In the presented research, we drew on various fields of knowledge from the natural, regional, historical, civic, or religious spheres. Our activities can serve as a model for garden conservators in Poland and Europe as part of the sustainable management of historical greenery. The case encourages us to consider situations of hasty cutting, which sometimes occur when we embark on conserving a historic garden. This means that when undertaking any new project, we should first aim to identify the health of the trees with the best possible modern methods and equipment and then reduce felling to a minimum while monitoring trees in weaker conditions and marking them with tape, fences, etc. The proposed measures demonstrate new possibilities in garden maintenance, landscape ecology, or landscape architecture.

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Article

Ethnicities in Post-Communist Romania: Spatial Dynamics, Fractionalisation, and Polarisation at the NUTS-3 Level

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Abstract: Scholars have shown a special interest in discovering and studying the role of ethnic diversity and spatiality at the country and region levels. This study contributes to the theoretical debate on the spatial dynamics of ethnicities, with the aim of (1) determining the evolution of ethnic dynamics in post-communist Romania and (2) applying ethnic fractionalisation and polarisation indices. The study uses a mixed methods approach based on a descriptive statistics analysis and applies the fractionalisation and polarisation indices to Romania's NUTS-3 (i.e., county) level. The findings suggest that the ethnic spatial dynamics in post-communist Romania have shown a decrease in all ethnicities due to migration and low birth rates, with the exception of the Roma ethnicity, for whom the trend is increasing. Additionally, polarisation and fractionalisation indices have different evolutionary manifestations depending on the dynamics of the ethnic groups present in certain geographical areas. Although neither of the two analysed indices has witnessed profound change at the spatial level, these small changes in spatial and short-term ethnic diversity can help us advance knowledge about co-existence in ethnically diverse societies. Higher values of the two indices are obvious in several counties where ethnic Hungarians cohabitate with Romanians and other ethnicities. This discovery can inform policy-makers to implement more policies for the further peaceful co-existence of Hungarians, Romanians, and other ethnic groups in Transylvania and other western counties in Romania. Furthermore, as the population growth trend for the Roma ethnicity is upward, Romania has to implement proper policies and build better government infrastructure to counter social inequality against the Roma people. This will help curb potential conflicts between the Roma and other ethnic groups at the local level. Finally, as most ethnicities decreased in number in post-communist times, further attention needs to be paid to the erosion of ethnic diversity in Romania because this could have a negative impact on economic development, social trust, and democracy.

Keywords: Romania; ethnicities; fractionalisation; polarisation; NUTS-3 units

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1. Introduction

In recent decades, there have been various changes in the ethnic composition of countries. This development has aroused great interest among researchers who seek to discover and study the role of ethnic diversity in modern human society [1,2]. Ethnic diversity plays an important role in shaping socio-economic and political goals. Ethnic diversity is also relevant to various different public policies, including those relating to ethnic integration and migration.

Social scientists have measured ethnic diversity using various indices, but most of these indices treat ethnic fractionalisation and polarisation as time-invariant phenomena [3] (p. 1). Recent studies in ethnic fractionalisation have approached the time-variant issue of fractionalisation and polarisation based on immigration estimates [4] or different national units [5]. Alternatively, they considered only one country at a time [6]. In more recent times, some scholars have published articles that use time-varying measures of ethnic fractionalisation [7,8]; however, all of the indices used are very limited, either with regard to time-variation or the countries covered. The most relevant study for longer-term changes in ethnic fractionalisation studies is Lenka Drazanova's [3] Historical Index of Ethnic Fractionalisation (HIEF). The author introduced the HIEF dataset as a longer-term variant index for further ethnic fractionalisation studies. Additionally, the ethnic polarisation index has been studied more in relation to civil war and conflict issues. For instance, Schneider and Wiesehomeier [9] presented a correlation between *ethnic polarisation, potential conflict, and civil wars, while* Bhavnani and Modownik [10] examined how the relationship between ethnic polarisation and civil war could be moderated by different degrees of ethnic salience. However, we are not aware of any study on ethnicity that takes the short-term and space as variants of both fractionalisation and polarisation at national and/or regional levels in East Central Europe. Moreover, previous studies on ethnic diversity in Romania [11–13] only referenced the 1992 fractionalisation index for Romania or examined ethnic spatial centrality/periphery at the county level [14]. These studies do not compare the fractionalisation and polarisation indices at different time scales at the post-communist Romania county level.

By contributing to the background of ethnic studies literature, this study aims to identify the ethnic spatialisation of Romania in the post-communist period and to determine the ethnic dynamics in post-communist Romania at the NUTS-3 (i.e., county) level based on the ethnic fractionalisation and polarisation indices. Therefore, the specific objectives of this study are (1) to determine the numerical evolution and ethnic spatial dynamics in post-communist Romania and (2) to apply the index of ethnic fractionalisation and ethnic polarisation.

The key questions of the paper are:

(a) How has ethnicity evolved in Romania in post-communism at the NUTS-3 (i.e., county) level?
(b) Are there spatial changes in the fractionalisation and polarisation indices according to the official censuses of the post-communist period?

We conducted a literature review, followed by a brief historiography of the main ethnicities in Romania, the study area, and the presentation of the methods and data used in this study. Finally, we present the main results and discussions on the spatial evolution of ethnicity and the indices of ethnic polarisation and ethnic fractionalisation.

Literature Review: Ethnicities, Fractionalisation, and Polarisation

Yang [2] considers that *ethnicity* is not a precise and clear concept but is subject to different interpretations. This is because some authors understand it as ancestry, and others perceive it as a physical attribute. The classic definition of 'ethnicity' is presented by Glazer and Moynihan [15]. They define it as the feature of belonging to a particular ethnic group. In contrast, Rogers Brubaker proposes an alternative approach, different from the classical anthropological approach, defining *ethnicity* as a way of seeing and perceiving the world around, as well as social self-identification (whereby individuals identify themselves with certain social groups) [1]. A study by Walker Connor shows that ethnicity and nationalism underlie the construction of the nation-state and are based both on elements of kinship due to common ancestry and psychological ties [16]. Furthermore, Wallerstein and Gordon [17] used this term to designate the sense of belonging to a particular people or community of subgroups in American society. According to Craig Calhoun [18], ethnicity is a concept used in relation to groups that share a combination of cultural, historical, racial, religious, or linguistic characteristics; often, ethnicity implies common ancestral origins and, as such, overlaps in meaning with the concept of people—which was used earlier—or certainly more modern conceptions of race. A prescriptive explanation of ethnicity is proposed by Cashmore [19], who defines it as an indispensable characteristic of a social group whose distinctive elements will be perpetuated and transmitted from one generation to another. However, in some cases, the term "ethnicity" is used in conjunction with "ethnic minority" or "ethnic group". According to Crețan [13], *ethnicity* can be broadly defined as belonging to or identifying with an ethnic group, the notion being synonymous with terms such as ethnic group members, ethnic identity, and ethnic affiliation.

Ethnic groups are defined as distinct population groups within a society whose culture is different from that of the majority population (from mainstream culture) [19]. Furthermore, an *ethnic minority* would represent a social entity that does not constitute a dominant group in the total population of a given society. This usually designates foreign, outsider people who are different from the native population [20]. The key concept in defining ethnic minorities is culture. The specific culture of an ethnic minority refers to the system of meanings shared and developed in an economic and social context against a specific historical and political background.

The basis of building a healthy multi-ethnic human society is the identification and maintenance of *ethnic identity*. Julia Chaitin et al. [21] (p. 7) argued that ethnic identity could be considered a fundamental and permanent aspect of human identity that claims the existence of a common origin. According to Descartes [22] (p. 57), ethnic identity represents a social construct, including culture, language, collective origin, and shared cultural traditions. The objective approach to the concept of ethnicity implies that belonging to a particular ethnic group requires the existence of criteria regarding homogeneous particularities, such as origin, language, culture, etc., or their combination. However, the subjective approach assumes that people are convinced that they are part of a particular community, with importance placed on individual self-inclusion. Although ethnicity can be subjectively identified as a product of human feelings, objectively, it is a construction of social relations [22].

Researchers have developed various theories of ethnicity in the existing literature, including primordialism, situationism, constructionism, and instrumentalism. From the perspective of *primordialist theory*, ethnicity will never disappear, rather experiencing a continuous development. Under this theory, ethnicity has a socio-biological perspective that represents the extension of kinship relations, the biological factor being very important in the development of ethnicity [23]. On the other hand, Gryosby [24] argues that ethnic groups and nationalities exist because there are traditions of belief and action towards primordial objects, such as biological factors and territorial location. This argument is based on a concept of kinship, where members of an ethnic group feel that they share characteristics, origins, or sometimes even a family relationship. Yang [2] also argues that ethnicity is based on kinship relations—it exists and is able to develop because of the existence of a common origin. According to primordialist theory, ethnicity is the deepest layer of a person's identity. In other words, in the primordialist conception, ethnicity is the essence of an individual's socio-cultural self, which determines the manifestation of other forms of belonging (e.g., gender, social category/class, political affiliation, etc.) [25].

The theory of *situationism* is in contrast to the primordialist view of ethnicity. According to this theory, changes in human behaviour are situational factors rather than traits that a person possesses [26]. The concept of 'ethnicity' would be the cultural repertoire of people that is contextually made available to individuals. Therefore, ethnicity marks the interaction between individuals based on their affections and strategic interests in various situations. According to situationism, the norms imposed by ethnicity may, in some situations, determine a certain type of behaviour.

The *constructivist theory* emerged as a new theory in 1970. According to Yang [2], this theory is based on two principles: (1) ethnicity is a created entity and social construction, and (2) ethnic boundaries are flexible and can be changed. Therefore, it can be stated that ethnicity is dynamic, representing the reaction to certain social circumstances. Basically, society determines or builds ethnic belonging or affiliation. Yancey et al. [27] believed that ethnicity would represent "a response to structural changes in society", speaking of the perspective of "emergent ethnicity" (p. 392). Moreover, Jonathan Sarna [28] initiated the two social features of the theory of ethnicity: attribution and adversity. "Attribution" means that the members of an ethnic group are part of a cohesive community within the school or church, and "adversity" implies prejudice, discrimination, and hostility in the same ethnic group, which forces the members of the same group to unite, thus maintaining the group's identity and solidarity.

From the point of view of *instrumentalism*, ethnicity is a tool to obtain resources. It is considered that the basis of ethnicity is determined by the general and economic interests of the individual [29] and that ethnicity exists because it is useful [2]. Brubaker [30] considered that ethnicity could be identified with the concept of nationality, arguing that ethnic heterogeneity, which characterises most states, coincides with national heterogeneity. Cohen [31] also took an instrumentalist view of the concept of ethnicity, stating that economic and political reasons take precedence over psychological ones within ethnic groups in order for ethnic identity to be maintained. Taking up this idea, Banks [32] also considered 'ethnic identity' to be instrumental in nature. In addition, the cohesion of ethnicity can be ensured by certain complex behavioural patterns, such as the use of a certain language and participation in certain religious and public rituals [33]. According to Williams [34] and Banks [32], ethnicity equates to the country of origin and can only be understood in relation to the notions of state and nation. However, it is worth noting that, ethnically speaking, the vast majority of states around the world are characterised by heterogeneity [35]. However, it should also be pointed out that in some states, some ethnic groups consider themselves, or are considered by others, to belong to different nations, nationalities, or national groups [36].

In summary, there is no uniform criterion on how to define ethnicity. Group identities are complex and mostly socially constructed, depending on the school of ethnic theories to which the scholars adhere. Furthermore, ethnic fractionalisation and polarisation indices are among the most used indices in measuring ethnicities. In order to overcome the possible shortcomings in constructing ethnic classifications, Alesina et al. [37] proposed a classification that distinguishes between ethnic, linguistic, and religious diversity. They created separate indices for each factor because relying only on one factor, i.e., linguistic distinctions, could obscure other aspects of ethnicity (i.e., racial origin, skin colour). On the other hand, Campos and Kuzeyev [38] used data from post-communist countries to introduce time-sensitive fractionalisation indices to endogenise the relationship between ethnic heterogeneity and growth (see also [39]). Their findings show that while ethnic fractionalisation has little or no impact on economic growth when treated exogenously, it is negatively related to growth when analysed endogenously.

There have also been efforts to overcome simple fractionalisation measures by focusing on conjunctures with other heterogeneities, such as the index of ethnic inequality [40]. Moreover, sociologist Peter Blau [41] argued that heterogeneity—the distribution of a population into multiple categories of group membership—is positively associated with the likelihood of intergroup relations. The Historical Index of Ethnic Fractionalisation (HIEF) introduced by Drazanova [3] seems to be the best ethnic fractionalisation index for analysing long-term historical ethnic datasets. The author argued that time variance is crucial in ethnic fragmentation studies.

On the other hand, the ethnic polarisation index is more commonly used in conflict studies. Bhavnani and Modownik [10] examined how the relationship between ethnic polarisation and civil war could be moderated by different degrees of ethnic salience (i.e., fixed and variable). Holding ethnic salience fixed effectively amplifies the negative effect of polarisation on economic performance. Moreover, Schneider and Wiesehomeier [9] gave their insight into the ethnic polarisation-conflict link by coding and classifying conflict and highlighting the distinction between conflict incidence and conflict onset. They argued that highly polarised countries do not experience more civil war than countries characterised by lower levels of polarisation. They also suggested that fractionalisation, rather than polarisation, is negatively associated with economic growth.

Our paper contributes to the above-mentioned theoretical debates by arguing that ethnic fractionalisation and polarisation indices could be used as short-term and spatial variants because changes in the spatial and short-term ethnic diversity can help advance knowledge about co-existence in ethnically diverse societies.

2. Methods and Data

This paper uses a mixed methods approach. We use an archival methodology and descriptive statistics to present the spatial dynamics of ethnicities. Furthermore, two ethnic indices (fractionalisation and polarisation) were used to determine if there are specific tendencies at the county level in post-communist Romania.

We selected the historical literature of all major ethnic groups in Romania to contextualise their historical geographies and spatial position within Romania. The archival methodology is not only applied to past histories but also to analysing digital texts, including electronic databases, e-mails, and web pages [42]. The archival research method was used to obtain several sets of statistical data from INS Romania (i.e., the national statistical office of Romania). Furthermore, we plotted graphs based on these sets of statistical data using the descriptive statistical method. These graphs are used to present the ethnic structure of the Romanian population. We then made comparative sets of data on ethnic structure and interpreted the results obtained. Descriptive statistics, which deals exclusively with the properties of observed data, can be used to summarise population data in data analysis [43]. A descriptive statistic is a summary statistic that quantitatively describes or summarises the features of a collection of information [44]. Finally, we calculated the indices of ethnic fractionalisation and ethnic polarisation at the county level in Romania.

In investigating the ethnic structure of human society and being able to assess social diversity implicitly, the literature states that the weight of some ethnic groups in a total population is of limited use. Therefore, two fundamental indicators/indices are used in addition, namely the fragmentation index, also called the fractionalisation index (FRAC) and the polarisation index (Q) [45–49]. Both indices can be applied, irrespective of the intergroup demarcation criteria, whether ethnic, confessional, or linguistic.

According to Taylor and Hudson [48] (Equation (1)), the fragmentation or fractionalisation index (FRAC) is determined as follows:

$$FRAC = 1 - \sum_{i=1}^{n} pi^2 \tag{1}$$

where

n = number of ethnic groups;

p_i = the relative proportion/frequency/empirical ratio in the form of a coefficient of the ethnic group 'i' in the total population, which is determined as the ratio/fraction between the number of inhabitants of the ethnic group 'i' and the total number of inhabitants.

The ethnic fractionalisation index usually measures diversity as a steadily increasing function of the number of groups in a country. It is based on the probability that two individuals drawn randomly from a country belong to two different ethnic groups. The FRAC index takes values between 0 and 1, where 0 is a perfectly homogeneous population from an ethnic point of view (i.e., when all individuals are members of the same group). If the number of ethnic groups increases, the value of this index will also increase. However, it never reaches 1 since 1 means that each individual belongs to his/her own group, and all groups would have only one member [48]. The FRAC index is quite limited and even controversial, especially in terms of its use in ethnic studies. Most researchers in the field believe that inter-ethnic violence is lower in very homogeneous or very heterogeneous communities.

According to Esteban and Ray [45], the polarisation index (Q) measures the probability of a potential conflict that may occur between two equal groups. In this paper we use the Reynal-Querol polarisation index (Equation (2) [47]. This index is determined as follows:

$$Q = 1 - \sum_{i=1}^{n} \left(\frac{0.5 - p_i}{0.5} \right)^2 p_i \tag{2}$$

where

n = number of ethnic groups;

p_i = the relative proportion/frequency/empirical ratio in the form of a coefficient of ethnic group 'i' in the total population, which is determined as the ratio/fraction between the number of inhabitants of ethnic group 'i' and the total number of inhabitants.

The polarisation index Q measures the standardised distance of an ethnic distribution from a bimodal distribution (bimodal distribution occurs when there are two perfectly equal groups in a community, i.e., each group represents 50% of the community). As well as measuring a particular aspect of population structure, Q also indicates the extent to which one group may perceive another group as a threat to its interests, validating the hypothesis that the most conflict-prone ethnic configuration would be one in which a majority co-exists alongside a sizeable minority. In game theory, this situation may be the natural tendency of the two groups to represent their situation as a zero-sum game [45].

The statistical data were processed using GIS (Geographic Information Systems) in order to apply the fractionalisation and polarisation indices. GIS offers the possibility of an awareness of different situations in real time and space [50]. ArcMap 10.8.2 software (with license provided by Department of Geography, West University of Timişoara, Timişoara, Romania) was used to produce thematic maps, including ethnicity cartographic diagrams and diachronic maps, to determine differences in ethnic dynamics. In order to create the maps, we used digital data from Esri Romania, available in vector format and free of charge at www.geo-spatial.org (accessed on 15 January 2023) [51]. The fractionalisation and ethnic polarisation indices were calculated in the vector data-attribute table (polygons represent the boundaries of Romania's administrative/territorial units). The entire analysis is carried out at the administrative units (counties) level, equivalent to NUTS-3 at the European level. The analysis includes data from the 1992, 2002, and 2011 censuses [52].

One of the methodological limitations of this study is that it did not include the recent 2021 census in Romania because its data were only preliminary at the time of writing this paper (February 2023) and did not have a definitive form of data processing at the county level. Another limitation is that this study does not analyse the situation of ethnic groups at the urban and rural levels. This is an objective for future studies.

3. Study Area and Short Historiography of Ethnicities in Romania

3.1. Study Area

Romania is a country in East Central Europe, situated at the southeast and eastern border of the European Union. Its neighbouring countries are Hungary, Serbia, Bulgaria, Moldova, and Ukraine. Romania has an area of 238,397 sq km, with a population of under 19 million inhabitants (2022), making it the 12th largest European country and the sixth most populous state in the European Union.

Apart from Romanians, the most important ethnicities in Romania are Hungarians, Roma, Germans, Ukrainians, Russian-Lipovans, Jews, Turks, Tatars, Armenians, Bulgarians, Serbs, Croats, Czechs, Slovaks, Poles, and Greeks (Table 1). An analysis showed that the main ethnic group in Romania is Romanians, followed by Hungarians, and the Roma, whose share is increasing, reaching about 3% of the stable population in Romania. The other ethnicities in Romania each account for less than 1% of the total population.

An important point to note is that a high percentage (over 6%) of the population did not declare their ethnicity in the 2011 population census, compared to about 0.01% in the previous (2002) census. The ethnic structure of Romania's population in the post-communist period has changed slightly from one census to another. However, there is a decrease in the population at a relatively slow pace, a trend that will probably continue in the coming years. Low birth rates and the immigration of younger people to Western European countries are among the major issues which have strongly impacted the decrease in ethnic groups in Romania in the three decades. For instance, Romania's crude birth rate decreased from 13.5 per 1000 total population in 1992 to around 10.0 per 1000 total population in 2021 [52]. Moreover, the natural increase in population reduced from positive (68,000 inhabitants in 1990) to negative values (−119,000 inhabitants in

2020) [52]. Poor living standards and the lack of a job/occupation have been among the main reasons for immigration. Germany, the UK, Italy, Austria, and Spain were the main destination countries for Romanian migrants in post-communist times. On the other hand, although immigrants/asylum seekers in Romania increased in the last decade to about 170,000 people [52], Romania is still not as much of an attractive country for immigrants from Asian and African countries when compared to most Western European countries.

Table 1. Dynamics of the ethnic structure of Romania's population in post-communist times.

	Census Year					
	1992		2002		2011	
Ethnicities	**Number of Persons**	**%**	**Number of Persons**	**%**	**Number of Persons**	**%**
Romanians	20,408,542	89.47	19,399,597	89.48	16,792,868	83.46
Hungarians	1,624,959	7.12	1,431,807	6.60	1,227,623	6.10
Roma	401,087	1.76	535,140	2.47	621,573	3.09
Germans	119,462	0.52	59,764	0.28	36,042	0.18
Ukrainians	65,472	0.29	61,098	0.28	50,920	0.25
Russians-Lipovans	38,606	0.17	35,791	0.17	23,487	0.12
Serbs, Croats, Slovenes	33,769	0.15	29,570	0.14	23,484	0.12
Turks	29,832	0.13	32,098	0.15	27,698	0.14
Tatars	24,596	0.11	23,935	0.11	20,282	0.10
Slovaks	19,594	0.09	17,226	0.08	13,654	0.07
Bulgarians	9851	0.04	8025	0.04	7336	0.04
Jews	8955	0.04	5785	0.03	3271	0.02
Czechs	5797	0.03	3941	0.02	2477	0.01
Poles	4232	0.02	3559	0.02	2543	0.01
Greeks	3940	0.02	6472	0.03	3668	0.02
Armenians	1957	0.01	1780	0.01	1361	0.01
Other ethnic groups	8618	0.04	23,445	0.11	26,544	0.13
Undeclared ethnicity	766	0.00	1941	0.01	1,236,810	6.15
Total	22,810,035	100.00	21,680,974	100.00	20,121,641	100.00

(Source: [52], accessed on 1 December 2022).

3.2. *A Brief Historiography of Ethnicities in Romania*

In order to better understand the origin of ethnic groups in Romania, we briefly present a historiography of Romania's major ethnic groups below.

The *Romanians* are Daco-Roman descendants, a people that came to be through the cohabitation of the Dacians and the Roman colonists in the northern part of the river Danube. They are a Latin-speaking population surrounded by the Slavic populations and the Hungarians.

After the Romanian state was created in 1918 due to the unification of its historical regions, the Romanians increased in number in the interwar period but had a short decrease in population during World War II. In the more recent evolution of Romanian ethnicity, there were noticeable increases during mid-late communist times due to state policies on the interdiction of abortion and the sustenance of birth rates. Moreover, internal migration in communist times was specific; people migrated from the less developed regions to the more industrialised regions of Romania [53]. There has been a noticeable decrease in general Romanian numbers since 1990 because of the freedom to migrate abroad and lower birth rates [13].

The *Hungarians* entered the history of Europe as one of the ethnicities that the great migrations pushed from the Asian steppes to Western Europe. The organisation of the Hungarian kingdom and the territorial expansion towards the east put the Hungarians in direct contact with the Romanians who had lived in Romanian-Slavic voivodships in the area of Bihor or the Banat region [54]. The presence of Hungarians in Transylvania was recorded by numerous medieval Hungarian chronicles [55]. In the Middle Ages, the Hungarian kings settled other populations in Transylvania and Banat [56]. Therefore, as the situation in the first centuries of the Middle Ages evolved, Transylvania became the cradle of a specific kind of civilisation, in which various ethnic groups, including Romanians, Hungarians, Germans, and Roma, co-existed in a complex relationship [57]. The Trianon Treaty and the creation of the Romanian national state at the beginning of the 20th century meant a new economic, political, and legal framework for the development of the Hungarians [58]. The consolidation of the communist regime under Soviet pressure also had negative consequences for the Hungarian minority in Romania. Nicolae Ceausescu's regime sought to further restrict the possibility of preserving national identity for all Romanian ethnicities [58,59].

History shows the existence of local conflicts between Romanians and Hungarians in Transylvania and other western Romanian settlements. However, the major clash between Hungarians and Romanians in the post-communist period was in March 1990 in the Transylvanian city of Târgu Mureș. Five deaths and hundreds of injuries were recorded. Tom Gallagher's study [60] revealed that members of the Vatra Romanesca Union—a regional/Transylvanian Romanian nationalist party—were considered to have played an important role in the degeneracy of the events leading to the clash. The clash began after it was proposed that an important high school in Târgu Mureș should be divided into two based on ethnicity. The proposal called for separate Romanian and Hungarian schools. Those events remained known as the Black March (Martie Negru in Romanian or Fekete Március in Hungarian).

It is not known exactly when the first *Roma* arrived in Romania. However, they are now an ethnic group found in all the counties of the country. Their massive migration to Europe is thought to have started in the 14th century, with most scholars believing that there were several waves of migration from India to Europe [61]. In the Middle Ages, they were considered non-Romanians and non-Christians and suffered enslavement in southern and eastern Romanian Principalities [62]. After the Great Union in 1918 and the creation of Romania, the number of Roma in the country increased. In the interwar period, the Roma emancipation movement began, and a new elite emerged. However, the Roma remained on the periphery of Romanian society, discriminated against and marginalised. During the Second World War, they were deported to Transnistria in camps built by the order of Marshal Ion Antonescu. The Nazis considered the Roma a "second-class nation" [63].

Later, the communist ideology in Romania led to the fuelling of nationalism, which sometimes emerged with hostilities of the Romanian majority against all ethnic neighbours but especially against the Roma [13]. Thousands of Roma families were forced to move to the outskirts of towns in socialist Romania in the 1950s in order to "cleanse" the big cities of the Roma. During the communist regime, the Roma were forced to give up their old occupations to work in agriculture, industry, or sanitation [64]. The Romanian communist state tried to stop the Roma from appearing as a nationality in official documents. At the same time, the Romanian communist state confiscated assets held by the Roma. As such, many Roma fled communist Romania to democratic countries [65].

After 1990 and the political regime change, the Roma regained their status as an ethnic minority. However, many Roma communities still suffer from poverty and social marginalisation, and they are sometimes victims of discrimination [66–69], which often leads to their social and spatial ghettoisation [13]. The Roma are vulnerable and exposed to both social exclusion and spatial segregation [70,71].

The Germans are another important ethnic group in Romania. The German ethnic group is made up of Saxons, Swabians, and "Zipseri (Ţipţeri)". The settlement of the Saxons in Transylvania began in the 12th century and lasted until the beginning of the 14th century for economic and military reasons. The Saxons were settled by the Hungarian kings in Transylvania (around Sibiu, Braşov, Sighisoara, and Năsăud) from Luxembourg, Saxony, Flanders, and the Moselle regions in order to defend the border of the Hungarian kingdom in southern Transylvania [72,73].

The second group of the German minority in Romania are the Swabians—the name given to the Germanic populations by their neighbours of other ethnic groups. Germanic populations were colonised in the 18th century by the emperors of the Habsburg Empire. The Danubian Swabians are made up of the Swabians of Banat and the Swabians of Satu Mare, as well as the Germans from Hungary and the former Yugoslav republics [74–77].

The third group of the German minority in Romania is made up of the "Zipseri (Ţipțeri)", found in Maramureş and Bucovina. The 'Ţipţeri' can also be found in the Spiš region of Slovakia, which is where this ethnic group immigrated to Romania [78]. Unlike the Saxons, the 'Ţipţeri' of Maramureș were mostly miners, while those of Bucovina (settled in the 17th and 19th centuries) were engaged in wood processing [79].

The ethnic group called the Turks is represented in the geographical region of Dobrogea, especially in the county of Constanța. They arrived in Romania in the middle of the 13th century in Dobrogea with a mission to spread the Islamic religion. Dobrogea was almost unpopulated at that time, with the "Golden Horde" to the north and the Byzantine Empire to the south. This historical Romanian province was removed from Ottoman rule and came under Romanian administration after the War of Independence in 1877. Under these circumstances, some Turks preferred to leave for their Muslim homeland after the collapse of the Ottoman Empire, while others remained in Romania, where their language, religion, and customs were respected [80].

Another small, Turkish-speaking ethnic group found in the Dobrogea region is the Tatars. They are of Mongolian-Turkish-Turanian origin. The first wave of Tatar migrants arrived in Dobrogea in the 13th century to spread the Islamic religion, followed by a second wave at the end of the 16th century. Towards the end of the 18th century, after the Tsarist Empire had increased its power and annexed Crimea, the Ottomans brought Crimean Tatars to Dobrogea, who, for the most part, had left Romania after the War of Independence in 1877. However, some preferred to stay on the Dobrogean lands, creating their own culture based on their history, religion, customs, and traditions [81].

The Lipovans/Russian-Lipovans are a small ethnic group of Slavic origin. They arrived in Romania in the 18th century as a result of Russian religious persecution. They came from the Don Valley areas in Russia and settled in the northern part of Dobrogea, especially in the Danube Delta, but also in Bucovina and Moldova, more precisely in the Constanța, Tulcea, and Brăila counties. They separated from the Russian Orthodox Church, as they did not agree to renounce their faith. They were called "raskolnici" (in Russian meaning "schismatics") or "staroveri" (in Russian, meaning "old believers") since their religion was the Old Rite Christian Orthodox religion. In history, two large waves of their emigration are known: the first wave—during the reign of Tsar Peter the Great and the second—during the reign of Tsarina Catherine the Great. Fishing, gardening, and viticulture are the main occupations of this ethnic group [82].

Serbs, Croats, and Slovenes are small ethnic groups of Slavic origin, mostly found in the southwest of the country, in the counties of Timiș, Caraș-Severin, Arad, and Mehedinți. Serbs emigrated from the Balkan Peninsula in successive waves. At the end of the 14th century, many Serbs—both commoners and nobles—emigrated across the entire territory of Romania, most of them to Banat, Crișana, and Transylvania. This was as a result of the strong Turkish penetration of the Balkans. Many Serbs had entered Banat even when it was under the Ottoman Empire. In the 17th–18th centuries, many Serbs settled in Banat on the Danube Gorges to defend the borders of the Empire, as Banat was under Habsburg rule at that time [83]. Most Serbs in Romania currently live in the southwest and west of the country. Serbs are Orthodox Christians, most of them are New Rite Orthodox Christians, but there are also some Old Rite Orthodox Christians [84].

Croats can be found in Romania in the counties of Caraş-Severin and Timis. Their colonisation also took place in successive waves in the 13th–14th centuries, and they were known as Carașoveni [85]. The dialect spoken by the Carașoveni was the Kosovo-Resava dialect [86]. Some of the Croats in Romania are descendants of the Slavicized Vlachs of Bosnia [87]. Today, most of the Caraşoveni claim to be Croats [85]. They are of the Roman Catholic religion [88].

There are very few Slovenes in Romania. Additionally, since they are identified as Serbs and Croats in the population census, their exact number cannot be identified. They are descendants of the South Slavs, their religion is Roman Catholic, and the language they speak is Slovenian [86].

Slovaks can be found in the west of Romania, in the counties of Arad, Bihor, Timiș, Sălaj, and Caraș-Severin [89]. They were colonised in the 18th century, with their primary occupation being forestry, mostly in mountainous areas but also in lowland areas (which had been affected by the wars with the Ottomans) and in mining areas in Maramureş and Satu Mare [90]. Specific to the Slovaks settled in Arad County is the fact that they did not create new settlements but settled in already existing settlements, where populations of other ethnic groups lived, forming their own nuclei of habitation (e.g., alleys or neighbourhoods) [91,92].

According to information from the City Hall Archives of Brasov, the Bulgarians arrived in Romania at the end of the 14th century, when Bulgarian builders were brought in to build the city church (Black Church) [93]. The builders settled in the Șchei district. Later, at the beginning of the 18th century, by fleeing from Ottoman rule, the Bulgarians also arrived in Banat, seeking a decent living after obtaining economic privileges from Habsburg rule [93]. Bulgarian migratory waves had been particularly strong after the Austro-Turkish and Russo-Turkish wars during the 17th–19th centuries [94], with Roman Catholic Bulgarians emigrating primarily to Banat [95] and Transylvania and Orthodox Bulgarians settling in Wallachia [94].

Another ethnic group with a very small population share in Romania is the Jews. Like other ethnic groups that call Romania home today, the colonisation of the Jews took place in several waves. By the middle of the 16th century, a group of Jewish merchants was already living in Bucharest. Other waves followed, caused by the difficult life situation of Jews in Galicia, starting in the second half of the 18th century [96]. The Jews in Romania have become a significant ethnic community since the 19th century, not only in terms of numbers but also economically, culturally, and even politically [97]. According to the 1930 census, there were 756,930 registered Jews living in Romania [52]. However, the fascist and anti-Semitic ideology also reached Romania, with legionaries leading to the physical elimination of ethnic Jews [96]. The establishment of the State of Israel in 1948 led to the emigration of Jews from Romania to their new homeland, resulting in a massive decline in their numbers [58]. Thus, only 24,667 people declared themselves to be of Jewish ethnicity in the 1977 census. By 1992, the number had dropped to 8955 [52].

The Czechs are a small ethnic group spread in the southeast of Banat, especially in the County of Caraş-Severin. Some of them also live in Mehedinţi, Timiş, and Arad. They were among the last colonised populations from around 1820 [98]. The Czechs first came to Romania to work in the forest as woodcutters but later became farmers, miners, or lime producers [99]. After the 1990s, many ethnic Czechs chose to leave the country because of diminishing economic opportunities and the desire to return to their country of origin [17].

The vast majority of Poles live in Suceava County, followed by Bucharest, Hunedoara, and Timiș. They were colonised at the end of the 18th century in Bucovina after this Romanian province became part of the Habsburg Empire. The Poles from Bochnia and Wieliczka were brought to work in the salt mines of Cacica. Some Poles preferred to settle in the Jiu Valley to work in the coal mines. However, some Poles emigrated to Bukovina for political reasons [100]. The occupation of Poland by Hitler in the Second World War led to the largest wave of Polish emigration to Romania [101].

Armenians are another ethnic group in Romania, with their presence in the country attested to for more than a thousand years. The historian Nicolae Iorga argued that the Armenians had arrived on the territory of Romania even before the formation of the Principality of Moldova, adding that it was not possible to trade without Armenians in Moldova ([102], see also [103]). Armenians are credited with building and developing Gherla as an important international trading centre [103]. Their presence in Wallachia has been mentioned since the 14th century [104].

The Greeks are an ethnic group whose presence in the current territory of Romania has been recorded since ancient times. Around 2700 years ago, ancient Greek communities colonised the Black Sea basin and built the first cities in Dobrogea, including Histria, Tomis, and Calatis. However, starting from the 17th century, Greeks in the Romanian Principalities began to hold important positions in the state, including the ruler of the country. During the reign of the Ottoman Porte, Greeks were appointed as Phanariots in Moldova and Wallachia [105]. At the beginning of the 19th century, the Greek aristocrats preferred to leave the Romanian Principalities after Greece gained independence. However, many Greeks from the lower social classes, such as merchants, sailors, etc., stayed back in Romania and continued to maintain their culture and traditions [106].

Romania is also home to ethnic groups, such as the Albanians, Italians (an ethnicity that migrated to Romania mainly after 1990), Chinese, and other ethnic minorities.

In summary, ethnic diversity has been present in Romanian territory for centuries due to complex historical factors. However, we do not find any important new ethnic groups settling in the country in the post-communist transition period. Romania is still not an attractive country for immigrants from Asia, Africa, and other continents.

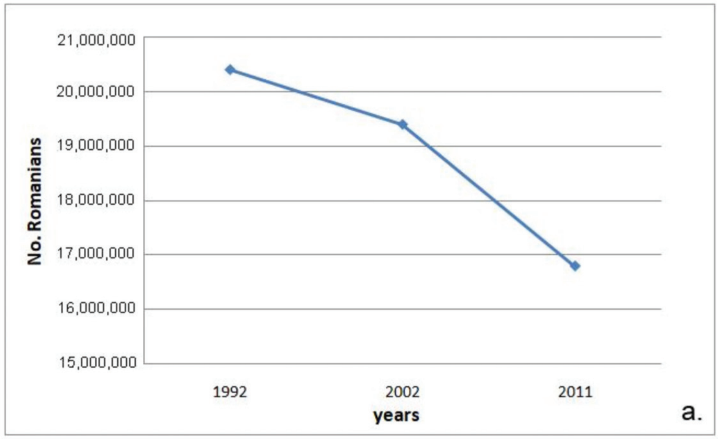
4. Results

4.1. Analysis of the Territorial Evolution of Ethnic Groups in Post-Communist Romania

This part of the study responds to the first key question of this paper, i.e., how has ethnicity evolved in Romania during post-communism at the NUTS-3 (i.e., county) level? When compared to Western Europe, where most countries are more economically developed and attract immigrants from different regions worldwide, Romania and other East Central European countries are not yet developed enough to become areas of attraction for immigrants. However, as presented in an earlier section, Romania is a country inhabited by many ethnic groups who settled in historically different times due to complex political and administrative issues.

An analysis of the timeline of ethnic groups in post-communist Romania is important to determine if the short time of 30 years of democracy has brought changes (decrease or increase) to ethnic groups.

Figure 1a shows that the number of Romanians began to decline relatively slowly in the early years of the post-communist period, and then the decline became increasingly steep. This situation is a consequence of the demographic policy that repealed "Decree no. 770 of 1 October 1966, regulating the interruption of women's pregnancy" in 1990, as well as the right to free movement, which led many Romanians to immigrate to Western European countries for a better living. The decreasing population trend is specific to all counties of the country (see Figure 1b), except for Ilfov County, where the number of Romanians increased. This was because many inhabitants of the nearby capital Bucharest preferred to leave the city for Ilfov County because of overcrowding. After the Romanians, Hungarians are the largest ethnic group in the country, with about 1.5 million people, constituting between 6% and 7% of the country's stable population during the post-communist period. However, the number of ethnic Hungarians in the post-communist period decreased relatively slowly in the 1990s. Therefore, the decrease of Hungarians became significant, both at the national level (see Figure 2a) and at NUTS-3 (see Figure 2c). This was due to the country's new demographic policy, which prioritises democracy, and the fact that many ethnic Hungarians emigrated to Hungary or other Western countries after acquiring the right of free movement.



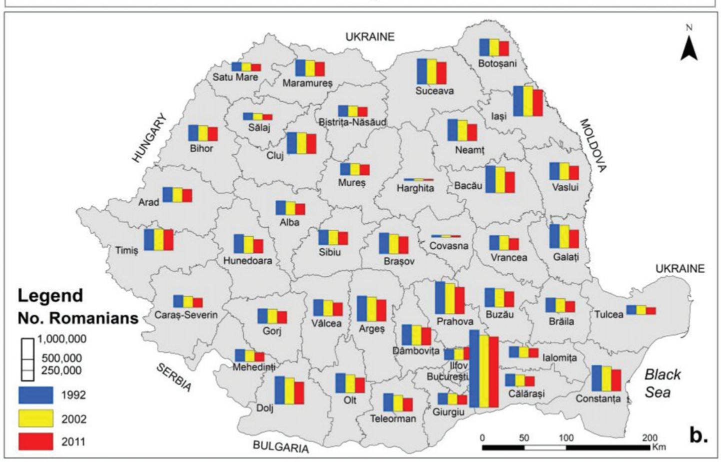
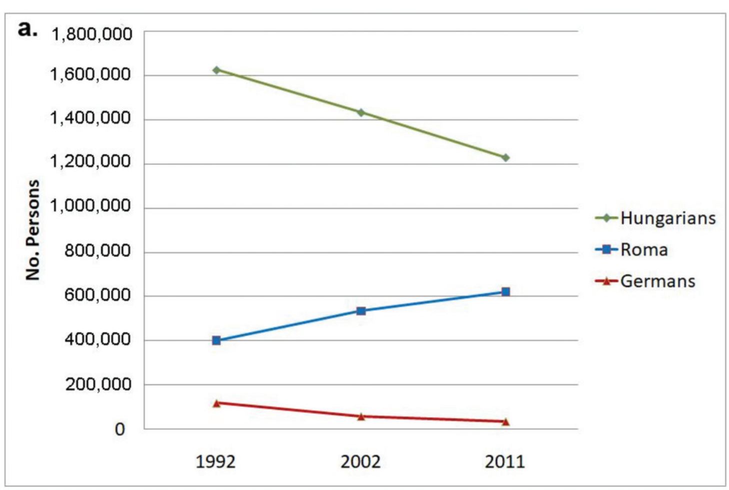


Figure 1. The numerical evolution of Romanian ethnicity according to the censuses of 1992, 2002, and 2011. ((**a**) National level; (**b**) NUTS-3 (i.e., county level).



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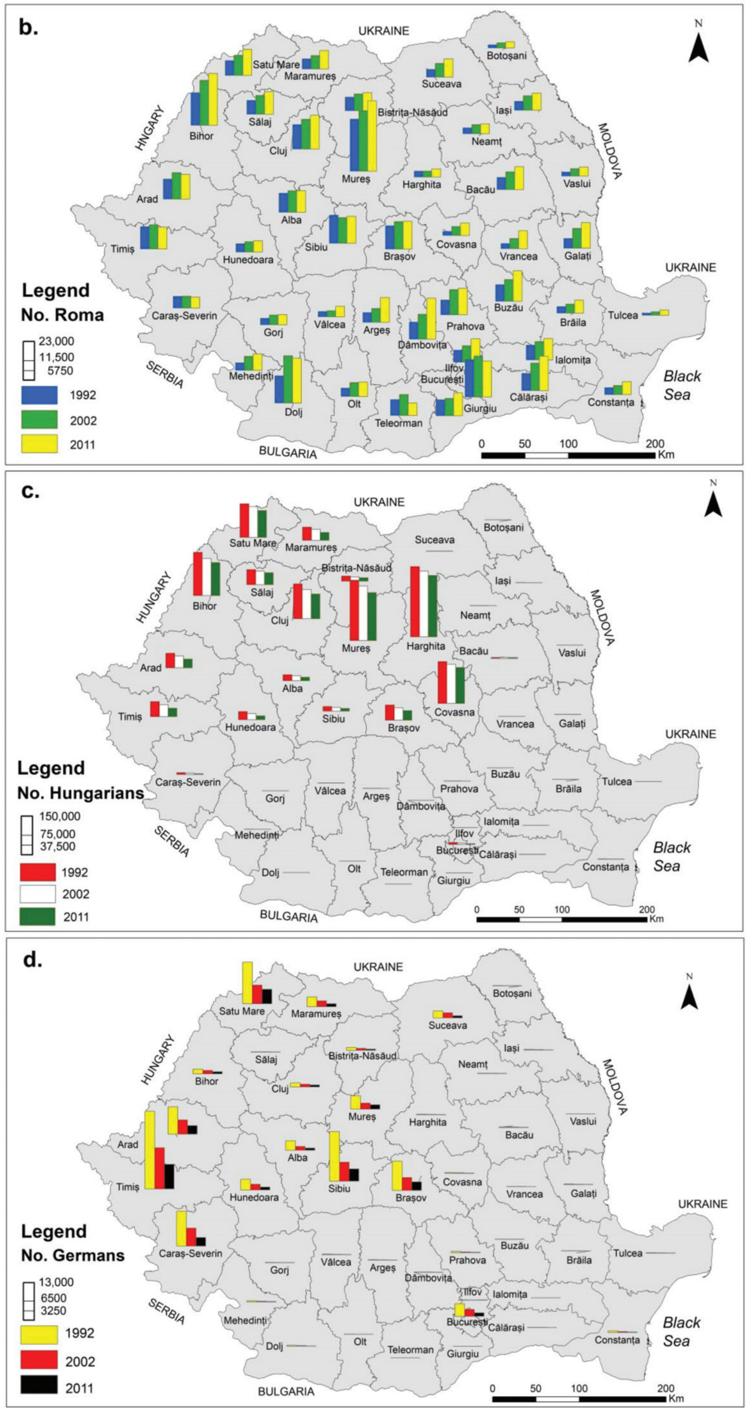


Figure 2. Numerical evolution of the Roma, Hungarian, and German minorities in Romania. ((**a**) Evolution at the national level; (**b**) evolution of Roma ethnic groups; (**c**) evolution of Hungarian ethnic groups; (**d**) evolution of German ethnic groups).

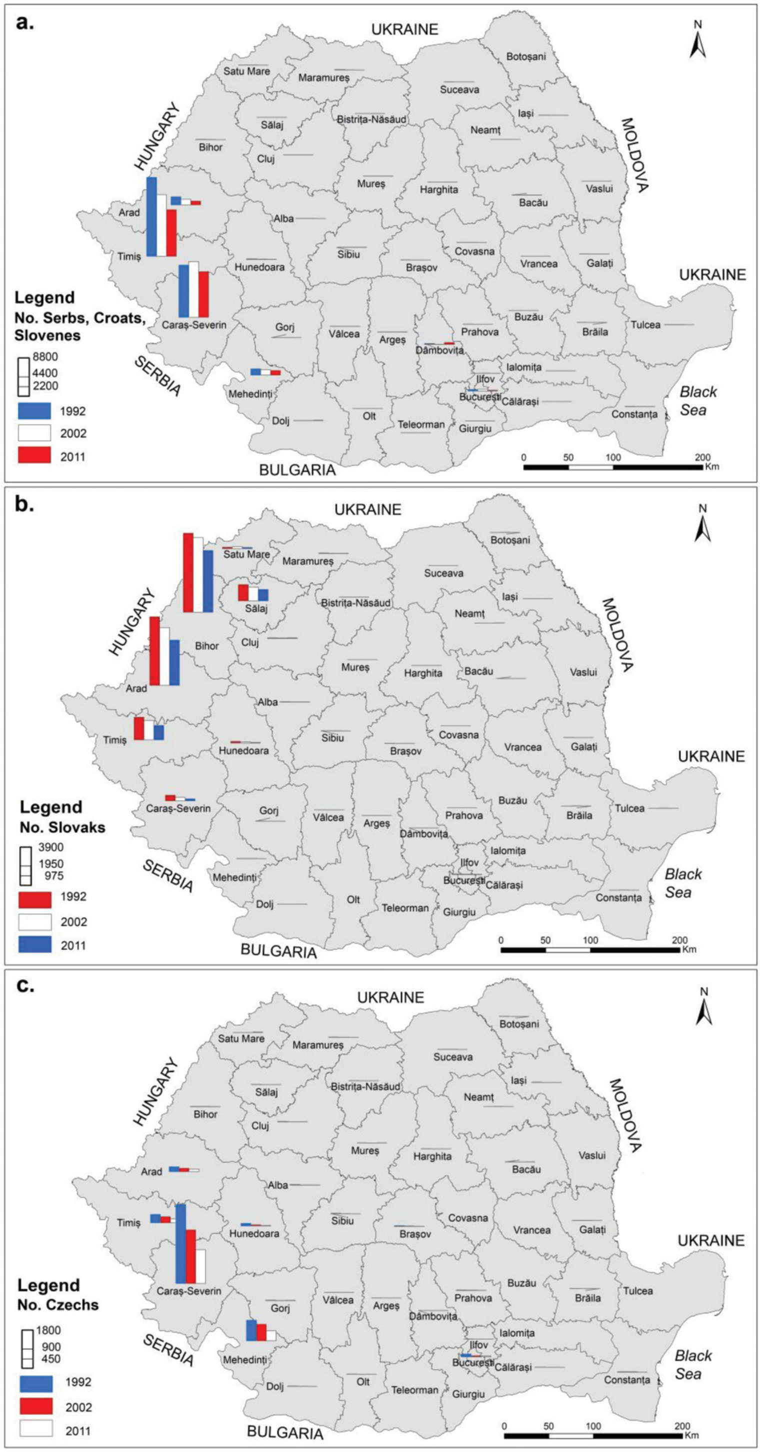
The analysis of statistical data for the Roma in the post-communist period shows that the number of ethnic Roma in Romania started to increase significantly (Figure 2b). This is because the Roma regained their ethnic status and were able to declare their ethnicity without any restrictions following the change of the political regime. At the county level, an increase in numbers of this ethnic group is noticed, except for counties in the south and west of the country. In the south and west, there was an increase in numbers, followed by a slight decrease in numbers due to immigration to Western countries (Germany, Spain, France, Austria, and the UK). Additionally, many Roma in those regions did not declare their ethnicity in order to avoid various stigmatisation or discrimination.

Many ethnic Germans in Romania migrated to Western Europe in the post-communist period, with their number almost halving (Figure 2d). At the same time, the processing of statistical data shows that the number of ethnic Germans is significant only in Banat, Transylvania, and Bucharest and that their population is constantly decreasing. On the other hand, after the fall of communism, democratic changes allowed the political, economic, and cultural affirmation of the German minority. In the last three decades, the German-language education network has been strengthened, cultural and scientific societies have resumed activities, new cultural and civil associations and societies have been founded, and numerous German-language media organisations have been established.

All the other smaller ethnic groups living in Romania have a much-decreased percentage of the total stable population of Romania and have encountered a numerical reduction in their population in the last few decades (Figure 3). For instance, Serbs, Croats, and Slovenes have significant numbers only in the Banat region (Figure 3a), while Czechs and Slovaks are mostly found in the counties of western Romania (Figure 3b,c).

Additionally, ethnic Ukrainians are still found in significant numbers only in the counties of Maramureș, Timiș, Caraș-Severin, and Tulcea (Figure 3d), while the Turks and Tatars are still an important ethnic group only in the counties of southeast Romania (Figure 3g,h). The Poles have significant numbers only in the northern Romanian counties (Figure 3e), and the Lipovans/Russians only in the Dobrogea and Bucovina regions of Romania (Figure 3i). Similarly, ethnic Greeks are found in significant numbers only in Bucharest and the counties of Constanța, Tulcea, Brăila, Galați, and Iași, with their number decreasing during the post-communist period (Figure 3j). Bulgarians have a core area in the southwestern and southern counties (Figure 3f), while Jews and Armenians are mostly represented in several cities and towns (see Figure 3k,l).

In conclusion, the population of most of the ethnic groups in post-communist Romania has decreased. Migration to Western Europe, lower birth rates, and the assimilation of smaller ethnic groups are among the major causes of this process. Only the Roma population recorded an increase in population due to its traditional larger family nuclei.



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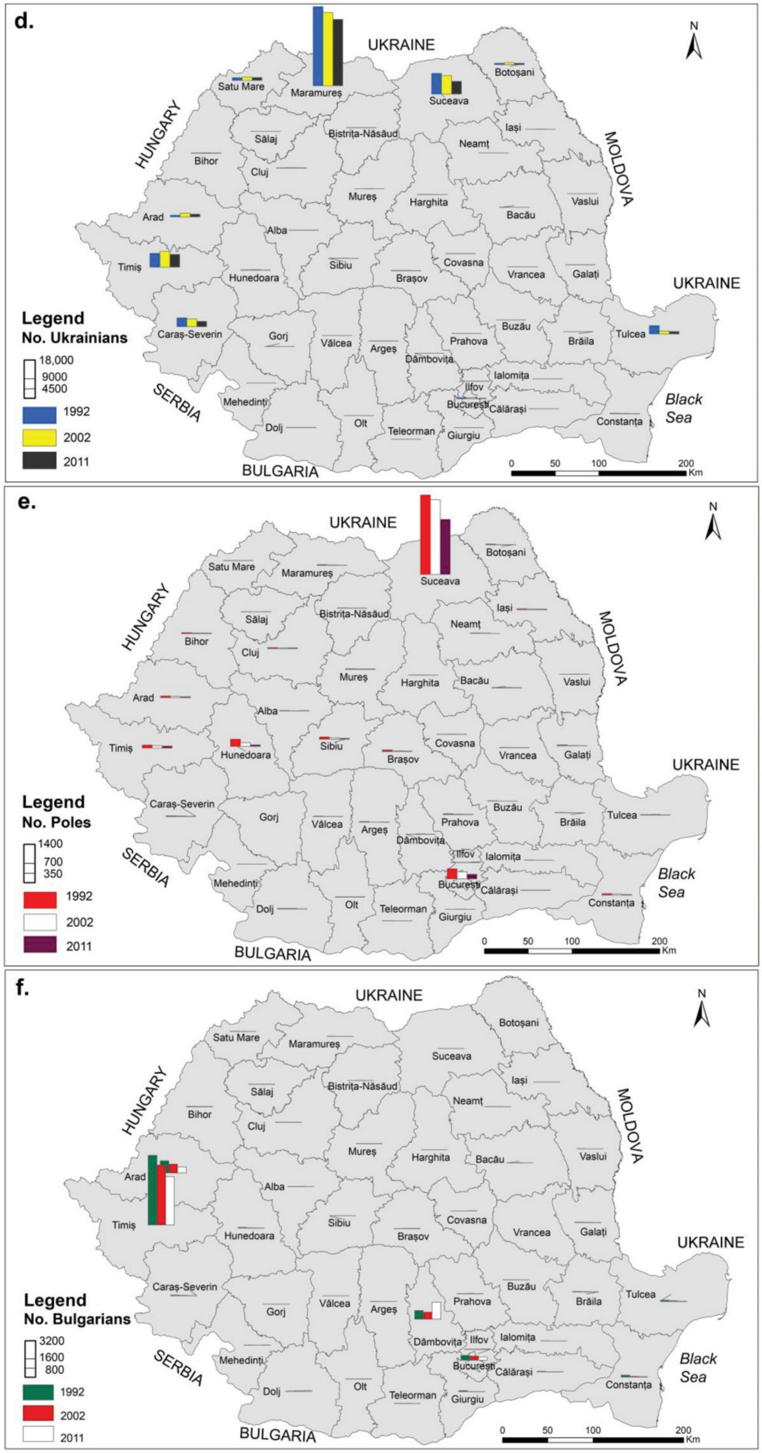

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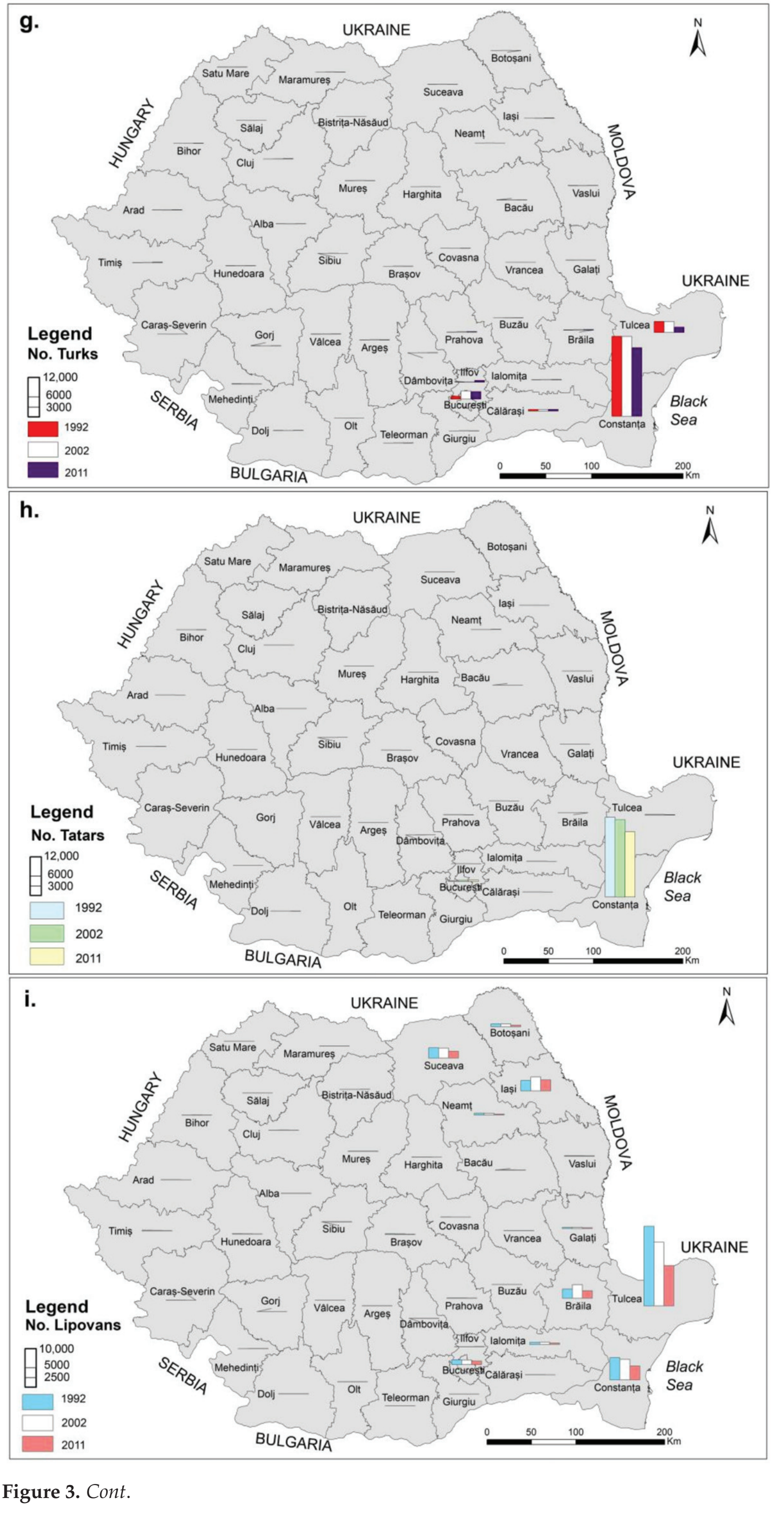

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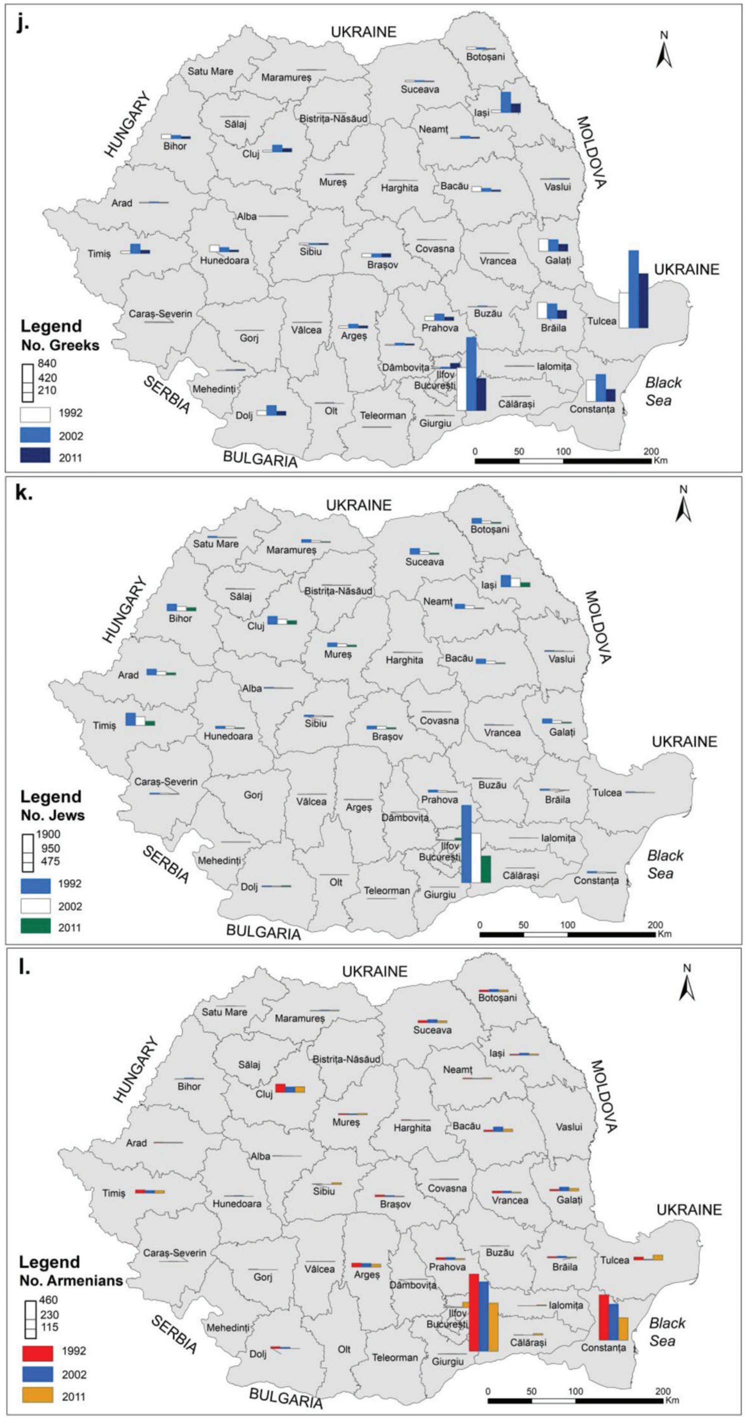


Figure 3. Numerical evolution of other ethnic groups in post-communist Romania. ((**a**) Serbs, Croats, and Slovenes; (**b**) Slovaks; (**c**) Czechs; (**d**) Ukrainians; (**e**) Poles; (**f**) Bulgarians; (**g**) Turks; (**h**) Tatars; (**i**) Lipovans; (**j**) Greeks; (**k**) Jews; (**l**) Armenians).

4.2. Fractionalisation and Polarisation Indices in the Spatial Investigation of Ethnic Evolution

Analysing the long or short-term effects and time-varying changes of ethnic diversity in a population could help us advance our knowledge of peaceful co-existence in ethnically and confessionally diverse societies. For this purpose, fractionalisation and polarisation indices are used, successfully measuring diversity as a steadily increasing function of the number of groups in a country based on the probability that two individuals randomly drawn from a country belong to two different ethnic groups [48]. To this end, we attempt to answer the second question of this paper, i.e., if there are spatial changes in the fractionalisation and polarisation indices according to the official censuses of the post-communist period.

Based on post-communist population census data and using the fractionalisation index formula (FRAC), we obtained data on ethnic fractionalisation at the NUTS-3 (i.e., county) level (Table 2).

Table 2. Ethnic Fractionalization Index at the NUTS-3 (i.e., county) level in Romania.

County	FRAC INDEX		
	1992	2002	2011
ALBA	0.1836	0.1782	0.2662
ARGEȘ	0.0216	0.0313	0.1280
ARAD	0.3348	0.3117	0.3617
BUCUREȘTI	0.0471	0.0583	0.2473
BACĂU	0.0388	0.0497	0.1742
BIHOR	0.4750	0.4759	0.5310
BISTRIȚA-NĂSĂUD	0.1773	0.1807	0.2456
BRĂILA	0.0383	0.0544	0.1703
BOTOȘANI	0.0170	0.0237	0.1127
BRAȘOV	0.2501	0.2295	0.3086
BUZĂU	0.0433	0.0585	0.1723
CLUJ	0.3581	0.3387	0.4049
CĂLĂRAȘI	0.0701	0.1109	0.2736
CARAȘ-SEVERIN	0.2477	0.2185	0.3104
CONSTANȚA	0.1577	0.1645	0.2947
COVASNA	0.3790	0.4005	0.4392
DAMBOVIȚA	0.0452	0.0636	0.1745
DOLJ	0.0492	0.0864	0.1842
GORJ	0.0248	0.0348	0.1113
GALAȚI	0.0253	0.0468	0.1835
GIURGIU	0.0680	0.0764	0.2143
HUNEDOARA	0.1526	0.1375	0.2213
HARGHITA	0.2624	0.2641	0.2958
ILFOV	0.0584	0.0760	0.2197
IALOMIȚA	0.0672	0.0844	0.2155
IAȘI	0.0251	0.0384	0.1657
MEHEDINȚI	0.0491	0.0752	0.1979

Table 2. *Cont.*

County	FRAC INDEX		
	1992	**2002**	**2011**
MARAMUREȘ	0.3272	0.3142	0.3752
MUREȘ	0.5542	0.5570	0.6044
NEAMȚ	0.0186	0.0264	0.1243
OLT	0.0223	0.0379	0.1553
PRAHOVA	0.0269	0.0443	0.1246
SIBIU	0.2258	0.1760	0.2673
SĂLAJ	0.4219	0.4369	0.5063
SATU MARE	0.5329	0.5283	0.5886
SUCEAVA	0.0651	0.0722	0.1392
TULCEA	0.2075	0.1856	0.2752
TIMIȘ	0.3465	0.2967	0.3417
TELEORMAN	0.0435	0.0626	0.1666
VÂLCEA	0.0192	0.0243	0.1222
VRANCEA	0.0193	0.0368	0.1742
VASLUI	0.0125	0.0228	0.1463

The cartographic representation of the values obtained (see Figure 4) shows that the ethnic fragmentation of the population in Romania has undergone some changes during the post-communist period in the sense that it has increased in some counties. This means that the risk of interethnic conflict in those counties has also increased.

According to the 1992 and 2002 census data, all Romanian counties had an ethnic fractionalisation of the population at a moderate level. According to the 2011 census data, however, the ethnic fragmentation of the population in Mureş County exceeded the threshold of 0.6, translating into a high ethnic fragmentation, a development that could generate tensions and interethnic conflicts, with the risk of triggering them being high. The northeastern part of Romania, including Salaj, Satu Mare, and Bihor Counties, also had high values of fragmentation (0.5–0.6). It is noted that the ethnic fragmentation of the population in the counties of southern Muntenia and Dobrogea, as well as in the counties of Hunedoara and Alba, has also increased from a very low level to a low level. While this does not raise any great concern at the moment, the situation should nevertheless be carefully monitored in the future. On the other hand, the ethnic fragmentation of the population in the counties of Moldova, Oltenia, and northern Muntenia remained at very low values, while that of the population in the counties in western Romania (Timiș, Caraș-Severin, and Arad) for the ethnic fragmentation of the population remained at low values. On the other hand, there were average ethnic fractionalisation values in the counties in the northwest of the country (Bihor, Satu Mare, and Sălaj). Based on the same post-communist population census data and using the formula for the polarisation index (Q), we also obtained the values for ethnic polarisation at the NUTS-3 (i.e., county) level in Romania (Table 3).

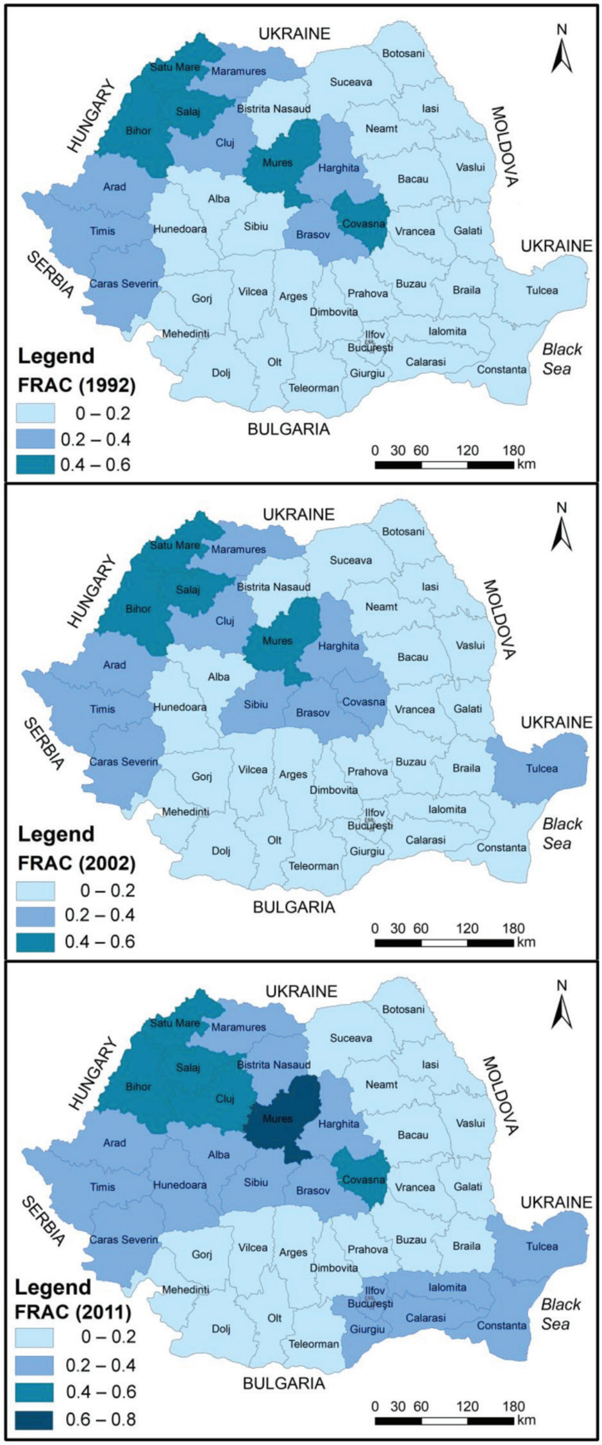


Figure 4. Evolution of the Ethnic Fractionalization Index at the NUTS-3 (i.e., county) level in Romania.

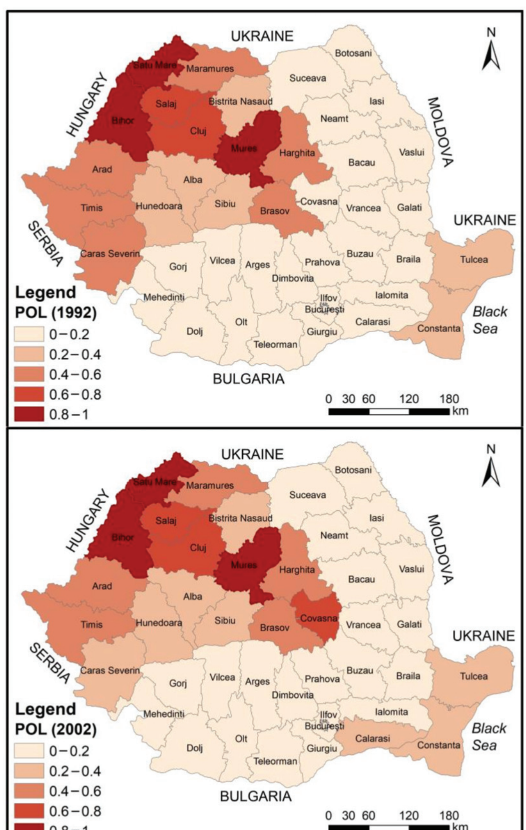
Table 3. Ethnic Polarization Index at NUTS-3 (i.e., county) level in Romania.

County	Ethnic Polarization Index		
	1992	**2002**	**2011**
ALBA	0.3388	0.3299	0.4562
ARGEȘ	0.0431	0.0623	0.2432
ARAD	0.5653	0.5168	0.5692
BUCUREȘTI	0.0918	0.1129	0.4641
BACĂU	0.0763	0.0975	0.3234
BIHOR	0.8292	0.8021	0.7878
BISTRIȚA-NĂSĂUD	0.3316	0.3357	0.4264
BRĂILA	0.0752	0.1062	0.3164
BOTOȘANI	0.0337	0.0469	0.2181
BRAȘOV	0.4530	0.4187	0.5138
BUZĂU	0.0865	0.1166	0.3210
CLUJ	0.6680	0.6228	0.6533
CĂLĂRAȘI	0.1392	0.2204	0.4844
CARAȘ-SEVERIN	0.4149	0.3769	0.5078
CONSTANȚA	0.2888	0.2997	0.4953
COVASNA	0.7290	0.7400	0.7359
DAMBOVIȚA	0.0897	0.1264	0.3234
DOLJ	0.0979	0.1717	0.3409
GORJ	0.0493	0.0693	0.2137
GALAȚI	0.0503	0.0928	0.3420
GIURGIU	0.1355	0.1524	0.3918
HUNEDOARA	0.2902	0.2618	0.3936
HARGHITA	0.5071	0.5091	0.5297
ILFOV	0.1160	0.1507	0.3983
IALOMIȚA	0.1334	0.1673	0.3930
IAȘI	0.0496	0.0756	0.3143
MEHEDINȚI	0.0960	0.1470	0.3617
MARAMUREȘ	0.5524	0.5316	0.5803
MUREȘ	0.9341	0.9234	0.8750
NEAMȚ	0.0370	0.0524	0.2399
OLT	0.0446	0.0757	0.2956
PRAHOVA	0.0534	0.0879	0.2374
SIBIU	0.3973	0.3212	0.4558
SĂLAJ	0.7556	0.7572	0.7714
SATU MARE	0.8944	0.8975	0.8521
SUCEAVA	0.1253	0.1386	0.2584
TULCEA	0.3787	0.3405	0.4662
TIMIȘ	0.5497	0.4881	0.5376
TELEORMAN	0.0869	0.1251	0.3169

Table 3. *Cont.*

County	Ethnic Polarization Index		
	1992	2002	2011
VÂLCEA	0.0383	0.0482	0.2342
VRANCEA	0.0385	0.0734	0.3254
VASLUI	0.0249	0.0456	0.2817

By mapping the values of the ethnic polarisation index (see Figure 5), it became clear that the ethnic polarisation of the Romanian population increased in the post-communist period. With the exception of Bihor County, where the value of the polarisation index decreased from a very high level (recorded in 1992 and 2002) to a high level only (in 2011), it increased or remained constant in all other counties, which means that the risk of interethnic conflict in some of the counties of the central western areas of Romania could also increase. It is also noted that the ethnic polarisation of the Romanian population has remained at a very low level in only one county—Gorj County in Oltenia. Meanwhile, there are also low values in Bucharest, Moldova, northern Muntenia, Oltenia and Alba County. This highlights that there should be no cause for potential concern regarding conflict at the moment, as the polarisation index has increased in these counties from very low to low values. Higher values of polarisation (over 0.7) are observed in the Transylvanian counties (Mures and Covasna), as well as in the counties of Bihor, Harghita, and Cluj, areas which should be monitored in the future for an upward trend.



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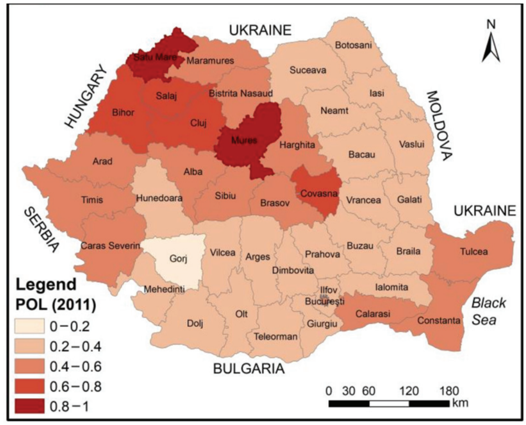

Figure 5. Evolution of the Ethnic Polarization Index at the NUTS-3 (i.e., county) level in Romania.

In conclusion, ethnic fractionalisation and polarisation can slightly change over short periods and at a regional spatial level, especially in areas where an important minority ethnic group, namely the Hungarians, cohabitate with an ethnic majority population and other ethnic groups.

5. Discussion

Romania is home to many ethnic groups who settled in different historical times due to complex political and administrative reasons. The analysis of the timeline of ethnic groups in post-communist Romania is important because the short 30 years of democracy had brought changes in the decrease in ethnic groups. Only the Roma population recorded an increase in number in most Romanian counties.

The existing literature highlights that an increase or decrease in ethnic diversity over time is likely to have very different consequences, even if people seem to adapt to the ethnic diversity of society over time [107]. For example, in the event of the dissolution of multi-ethnic states or the collapse of the communist regime, ethnic diversity could decline at a rapid pace, leading to completely different challenges for the new homogeneous societies. On the other hand, countries with increasing ethnic diversity may be more willing to introduce institutions to effectively manage the problems of more heterogeneous populations than countries with shorter histories of ethnically diverse societies and lower average rates of diversity change [108]. Failure to consider these historical developments could hinder our understanding of the effects of ethnic diversity on the population in a given region. As has been highlighted in this study, ethnic fractionalisation and polarisation can bring changes even over a short period and at the regional spatial level, mainly in areas where an important minority ethnic group co-exists with an ethnic majority population. In this case, Romania has to implement more cultural institutions in the areas of high fractionalisation and polarisation to manage potential friction between the Romanians and the Hungarians, especially in Transylvanian counties where Hungarians are present in a larger number. For instance, conflicts like those of March 1990 in Târgu Mureş should never happen.

Furthermore, there is a close correlation between the ethnic fragmentation and polarisation of the population in a given region and the risk of tensions. Conflict in society could appear at a given time [108]. Historical changes in ethnic diversity within countries are of particular importance in the countries of East Central Europe, of which Romania is a prime example. Even if Romania had not encountered major changes in the fragmentation and polarisation indices in post-communist times, particular attention still has to be paid to the erosion of ethnic diversity in Romania because this could negatively impact economic development, macroeconomic stability, social trust, participation in government, the quality of governance, democracy, and many other socio-economic outcomes [109,110]. Moreover, ethnic fragmentation could also have an impact on the distribution of consumption, which may have independent negative consequences, with the ethnic and confessional heterogeneity of the population negatively affecting the provision of public goods [111,112]. To compound matters, given the redistributive nature of public goods, their low provision could lead to the negative impact of ethnic fragmentation on social inequality [113,114].

Finally, high levels of social inequality can lead to conflict and crime [115], inefficient redistribution [116], high tax rates [117], and lower rates of economic growth in general [72]. For instance, our results show that the Roma people are growing in number in most of the counties in Romania. Therefore, the Romanian state has to put into practice certain laws against social inequality towards the Roma. On the other hand, some researchers [118] argue that it may be useful to rethink the assumption that ethnic diversity is relatively invariant over time, as changes in the ethnic heterogeneity of a population may play a role in the relationship between ethnic and denominational diversity and socio-economic outcomes. Ethnic diversity has reshaped and will continue to reshape social relations in Romania. For instance, as Blau [41] argued, when the parameters of heterogeneity are only weakly correlated, fewer subgroups are perfectly homogeneous in all aspects. This is one reason why Romania's ethnic dynamics have to be further studied. This will help determine if ethnic fractionalisation and polarisation will change at different spatial levels.

6. Conclusions

Ethnic diversity has always represented a significant aspect of population studies. Changes in ethnic heterogeneity over time might be relevant for the effects of ethnic fractionalisation and polarisation on diverse social, economic, and political outcomes. Previous studies have concluded that changes in ethnic diversity could have a negative impact on macroeconomic stability [119], governance [120], and economic development [107].

This paper argued that ethnic diversity is a time and spatial variant. Historical and spatial changes in heterogeneity might play a role in the relationship between ethnic diversity and social, economic, and political outcomes. From the post-communist ethnic evolution analysed, this study has shown that most of the ethnic groups in Romania recorded a decrease in population because of the opening of Romania's borders after 1989, leading to the massive migration of Germans, Romanians, and other ethnic groups. Another cause would be the general decrease in the ethnic birth rate. This decrease highlights an erosion of ethnic diversity in Romania, which could have a negative impact on economic development, social trust, democracy, and many other socio-economic outcomes. However, an exception to the decreasing population growth was noted in the Roma people, who are growing in numbers due to a higher natural increase in the traditional population. These aspects can inform policy-makers to build stronger institutions in order to counter social inequality against the Roma people (see also [66–69]) and curb potential conflicts between the Roma and other ethnic groups at the local level.

Ethnic polarisation and fractionalisation are important indicators of ethnic cohesion and diversity at the territorial level. The situation in Romania has changed only in small geographical areas, mainly in some counties in Transylvania where Hungarians co-exist with Romanians. Therefore, ethnic fractionalisation and polarisation in Romania have encountered slight changes in the decades after communism at the regional spatial level. These appeared mainly in areas where an important minority ethnic group co-exists with an ethnic majority population. In this case, Romania has to implement stronger policies and institutions to manage potential conflicts between the Hungarians, Romanians, and other ethnic groups in Transylvania and other western counties of Romania, where Hungarians are present in a larger number. This will help avoid a similar dreadful event, such as the March 1990 conflict of Târgu Mureș.

A broad limitation of this study is that it did not consider other diversity variables, such as language and religion, as we intend to include them in our future studies. It did not consider a longer historical perspective because our research interest was only in the ethnic diversity trends in post-communist times. Additionally, we did not connect ethnicities to economic growth or other socio-economic patterns. Finally, the recent Romanian census of 2021 could be a useful data tool for further ethnic diversity studies in Romania, but we could not rely on these data as they are currently available only as preliminary data. In this regard, future studies on Romanian ethnic diversity might determine if the trends in ethnic dynamics, including fractionalisation and polarisation, remain the same as in this study or if they change. Considering multiple variables in connection to ethnicities in Romania could be very useful for policy-makers. Comparative studies on ethnic diversity might also be conducted between different countries to observe the dynamics of the ethnic groups of the respective countries.

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buildings

Article

Quantitative Estimation of the Internal Spatio–Temporal Characteristics of Ancient Temple Heritage Space with Space Syntax Models: A Case Study of Daming Temple

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Abstract: Ancient temple heritage space is a subcategory of integrated spaces with profound religious architecture, culture, and landscape. The temporal and spatial characteristics, spatial layouts, and functionalities of ancient temples are gradually transformed during different periods in their development. However, quantitative topological estimation tools, e.g., space syntax and detailed digital spatial models, have seldom been adopted in related studies on ancient temples. Daming Temple is a typical representative of the revitalization of Buddhism monastic building heritage in China. This research studies the spaces of Daming Temple, Yangzhou City, in three different periods and explores its spatio–temporal characteristics based on two space syntax models, i.e., the angle segment analysis (ASA) model and the visibility map analysis (VGA) model. By multi-step quantitative estimation, changes in the mean depth (MD), mean connectivity, and intelligibility of the temple have been observed. The global spatial structure is thoroughly revealed, which indicates the changes in the 'temple-residence-garden' inter-relationship. It is indicated that dynamic spatio–temporal characteristics of the temple have been undergoing changes chronically. Some phenomena are found to be effective in offering reasonable explanations for these changes, i.e., the changes in relationships among spaces, visitors' pathfinding difficulties, and spatial design techniques. It also found that there are certain correlations between temporal–spatial changes and spatial conservation strategies for building heritages. The case study can provide some valuable references for the conservation, reactivation, and redesign of related historical and cultural building heritage in East Asia.

Keywords: space syntax; ancient temple; building heritage; spatio–temporal characteristics; spatial configuration

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1. Introduction

The ancient temple heritage space is one subcategory of integrated spaces with profound religious architecture, culture, and landscape, which is vital for cultural redevelopment, especially in East Asian countries. With the change and development over thousands of years, the spatial layouts and functionalities of temples in East Asia have been gradually transformed, while many temples have been destroyed or even disappeared due to certain causes, e.g., wartime destruction, lack of maintenance costs, and inappropriate techniques in conservation practices. Spatial planning, planting design, and natural aesthetic values are all the main factors that can affect the conservation and revitalization of ancient temples [1]. Cognitive mechanisms and the characteristics of isomorphic synaesthesia in ancient Chinese temples are also primarily analyzed by some researchers [2]. In recent years, there have been some studies focusing on quantitative estimation for the conservation and management of ancient temples and visitors' sensory perceptions of heritage. Six dimensions in ancient building spaces, i.e., "adoration", " nostalgia', 'liveliness', 'exquisiteness', 'hedonic value', and 'placeness' on visitors' aesthetic experiences are estimated by quantitative methods [3]. A netnographic approach for conducting narrative analysis on heritage tourism marketing is also put forward [4]. An information model of Chinese traditional garden heritage spaces is constructed to improve the accuracy of spatial information and management efficiency, which provides a more convenient solution for the conservation, redesign, and management of temple heritages [5].

Space syntax is a spatial topology algorithm developed by Bill Hillier to estimate and explain the correspondence between spatial form and function quantitatively [6]. The space syntax theory has been widely applied in interdisciplinary space-related fields, which is also applicable to the quantitative spatial estimation for heritage spaces [7]. Space syntax theory suggests that the core of spatial characteristics is the 'association' between spaces [8]. In the spatial configuration system, each geological factor is constrained by the other, and there is a complex internal topological relationship between each element [9]. 'Angular segment analysis' (ASA) and 'visibility graph analysis' (VGA) are two typical space syntax models that have been widely applied in most research, by which complex characteristics of the space are simplified and processed as a grid-based topological system consisting by interconnected constraints [10].

Both ASA and VGA models are effective in representing the spatial configuration changes and the influences by human beings on the space, visualized in a visual graphical language [11]. In the recent decade, spatial syntax has been applied to the study of multiple types of buildings and landscapes, especially been utilized as a convincing tool to assess the spatial organization of cultural heritage sites [12]. Spatial Differences among several typical ancient heritage palaces are compared by multiple space syntax models to guide restoration planning projects for those heritage redevelopment projects, especially for redesigning visitors' routes through the temple heritage [13]. The ASA and VGA models are also applied to estimate the spatial configuration in the case study of temple heritage, e.g., the Canaanite temples, which indicates that the temple heritage spaces are unique in their characteristics, not only in the role they play in the surrounding landscape and region but also in their distinction from the surrounding ancient temple heritage spaces [14].

Space syntax models have also been introduced into some reliable studies related to ancient temples in East Asia. Using spatial syntax modeling, the spatial structure of the Chinese building heritage has been revealed [15]. For instance, the Lion Grove Garden Temple heritage spaces in Suzhou City are estimated based on space syntax theory and found that spatial visual features affect the spatio–temporal distribution of visitors [16]. A space syntax-based analysis method has been developed to assist in improving tourists' spatial cognition in Chinese historic districts for urban designers and landscape architects [17].

However, there are still a few cases of space syntax in space, while the spatio–temporal structural evolution of ancient temples has not been learned thoroughly. Therefore, quantitative estimation by space syntax models is of high potential in the estimation of internal spatio–temporal characteristics of ancient temples, which can offer necessary guidance for the conservation, redesign, reactivation, and redevelopment of similar spaces.

2. Materials and Methods

2.1. Study Site

Daming Temple (119.41° E, 32.42° N) is one of the eight famous monasteries in Yangzhou City, China, which was built during 457–464 A.D. Monk Jianzhen (688–763 A.D., also known as 'Ganjin' in Japanese), the host of the Daming Temple, had once traveled eastward to Japan and built the Tōshōdai-ji Temple, which significantly accelerated the communication of Mahayana Buddhism culture between China and Japan. Daming Temple has been expanded several times. In the Sui Dynasty, Emperor Yang Jian built the Qiling Pagoda in Daming Temple. During the Northern Song Dynasty, some literati contributed to the design and construction of the temple, e.g., the literatus Ouyang Xiu (1007–1072 A.D.) designed the residence Pingshan Hall in the temple; Su Shi (1037–1101 A.D.), the well-known writer, calligrapher, and painter, designed and constructed the residence Guling Hall next to Pingshan Hall. During the reign of Qianlong (1736–1796 A.D.) in the Qing Dynasty, Wang Yinggeng (1680–1742 A.D.), a well-known merchant, built the West Garden in the temple, which was praised by Emperor Qianlong for its scenery. Referring to historical records and ancient literature [18], there was no noticeable change in the spatial layout of the Daming Temple from the end of the Qing Dynasty to 1962. From 1962 to 1973, Jianzhen Memorial Hall by the temple was designed and constructed, which dramatically affected the spatial layouts of the temple garden. After the 1990s, Daming Temple expanded the East District and the West Garden while changes in its spatial layout occurred. Since the 1990s, the financial revenue of the temple has been increasing rapidly for the redevelopment of tourism; thus, the temple's income has been able to cover the large-scale maintenance since the 2010s.

Daming Temple (Figure 1) is a typical representative of a re-activated Buddhism temple in China, which has undergone long-term alterations and expansions. There is an urgent need to study the building space of the Damien Monastery in order to advocate for the conservation and redevelopment of the temple's heritage. Historical maps of 3 periods of Daming Temple were selected respectively, considering the changes in new-built areas, i.e., the construction of Jianzhen Memorial Hall and the expansion of the East District since the 2000s.

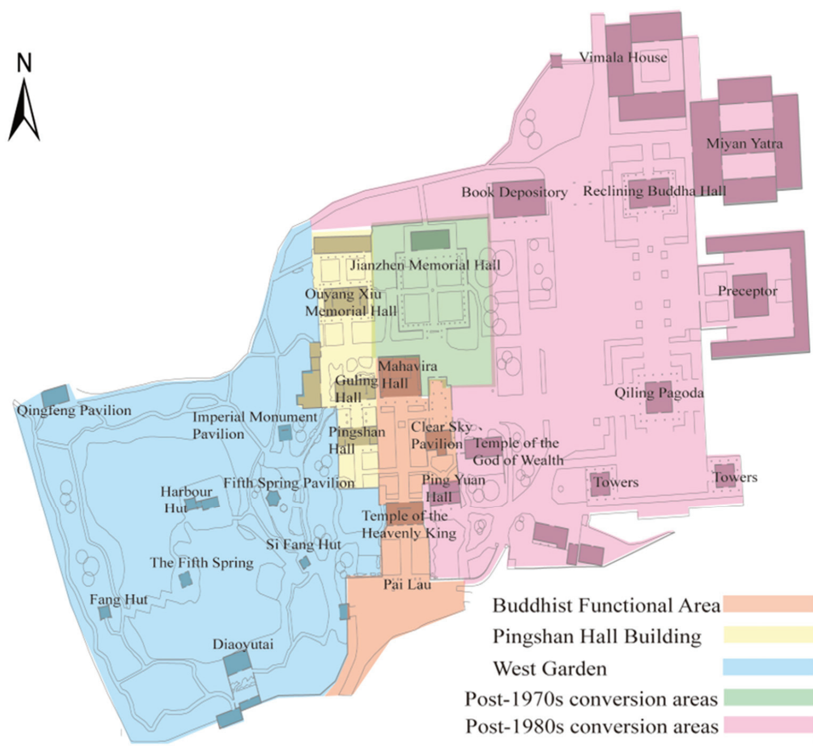

Figure 1. Two-dimensional map of spaces in the Daming Temple during different periods.

2.2. Methods of Quantitative Estimation

In the space syntax theory, the spatial structure analysis should focus on the 'spatial configuration', i.e., a set of complex relationships between spaces, all of which are interrelated in a global spatial structure. Spatial configuration can be visualized quantitatively by typical models, i.e., angular segment analysis (ASA), visibility graph analysis (VGA), and agent-based analysis (ABA). These models can reveal the comparability of measures of spatial configuration between different periods of space. The ASA model uses 'angular distance' rather than 'metric distance'. The 'angular distance' can represent the visitors' psychological and cognitive distance, such as the psychological distance expectation when they pass the steps. The visibility graph analysis (VGA) model in the space syntax system has also been widely adopted in small-and medium-scale spatial studies. As the temple heritage space has been redesigned several times, the structure of the space has changed accordingly. It is, therefore, necessary to visualize the spatial changes quantitatively. In typical Asian temple spaces, the levels of visibility and accessibility are often out of alignment, which can only be represented in the VGA model rather than the ASA model. Therefore, the study involves some parameters and indices in 2 space syntax models mentioned above, which are introduced as follows.

Some indices are commonly used in the ASA and VGA model, including 'Mean depth' (MD), normalized angle integration (NAIN), normalized angle choice (NACH) [19], and connectivity. In the space syntax system, 'depth' is the selected from the system or the amount of space passed through a given starting point. The MD value of a system is the average of all possible steps from a given starting point [20]. Angular segment integration (int.) shows how well each segment is integrated with all other segments, i.e., the total number of directional changes [21]. Angular choice shows the degree of integration of each segment of the path in terms of the lowest total number of angular deviations compared to all other segments. The angular choice analysis shows the potential for through movement in the spatial system [22].

Visual graph analysis (VGA) is a method for evaluating the inter-visibility of spaces. It builds upon the logic of an isovist analysis; it is different in that a visual graph analysis is derived from all the roots of each isovist field from each cell on a given raster. The VGA is applied at eye level (what people can see) and at knee level (where people can move) [23].

In both the ASA and VGA models, the value of connectivity is determined by the number of knots connected to the knot [24], calculated by Formula (1).

$$MD_i = \frac{\sum_{j=1}^{n} d_{ij}}{n-1}, i \neq j \tag{1}$$

where n—amount of knot in the system; d_{ij}—the shortest topological distance between any two points.

The MD value in the VGA model can also be further converted to obtain an 'integration' index. The MD metric is often utilized to express the spatial configuration quantitatively. The 'Connectivity' (con.) index is a static local measure and explains the number of connections that each segment has to its direct neighboring ones. The 'Mean connectivity' (mean con.) index is defined as the average of the connection values of all nodes in the global space [25].

In the ASA model, NACH and NAIN are also adopted in accordance with methods put forward by Hiller et al. [26]. The values of NAIN and NACH can be calculated by Formulas (2) and (3).

$$NAIN_i = n^{1.2} / \sum_{j=1}^{n-1} d(i-j), i \neq j \tag{2}$$

$$NACH_i = \frac{\log(\sigma_{s,t}(i)/\sigma_{s,t} + 1)}{\log\left(\sum_{j=1}^{n} d(i,j) + 3\right)}, i \neq j \tag{3}$$

where n is the total knot amount; d is the shortest distance between point i and point j.

The 'Intelligibility' index is an indicator of the correlation between the local and the whole in a spatial system. Relevant empirical studies [26] have shown that the intelligibility of space is higher, and visitors will not easily get lost in space, and vice versa. The 'Intelligibility' index can be calculated by the Formula (4).

$$R^2 = \frac{\left[\sum(C_i - \overline{C})(I_i - \overline{I})\right]^2}{\sum(C_i - \overline{C})^2 \sum(I_i - \overline{I})^2}, i \neq j \tag{4}$$

where $\overline{C}$ is the mean of all cell space connectivity values; $\overline{I}$ is the mean of all cell space global integrations.

'Configurational centrality' in spatial syntax is a concept used to describe the degree to which a particular location in a built environment is centrally located in relation to other locations within that environment. It is based on the idea that the spatial layout may affect the way visitors move through spaces [27,28].

2.3. Preparation of the Data

Two-dimensional plan maps of the Daming Temple in 3 periods are adopted in the study, i.e., two historical maps drawn by scholars Congzhou Chen (1918–2000 A.D.) of Tongji University in the 1960s and the 1970s and CAD maps drawn during the in situ survey conducted in 2022 by the Cultural Publicity Department of the Daming Temple, Jiangsu Province. To ensure the precision of the mapping, a short-term in situ survey was also conducted. Then, 3 versions of the survey map (Figure 2) were re-drawn in the software Rhinoceros 7 (a multi-functional parametric modeling software developed by Robert McNeel & Associates, Seattle, WA, USA) and input into the software DepthMap 1.0+ Beta (software developed by University College, London, UK). Some necessary manual modifications were performed based on the on-site mapping. During the movement of the visitors in the space, most of the space is relatively flat, with only a small difference in height between the articulated parts of the attraction and the attraction. These heights have little impact on the visitor's views; therefore, there is little potential to affect the accuracy of the VGA model. Simultaneously, in the ASA model, we used polylines based on the principles of modeling from a spatial syntax perspective, as described later.

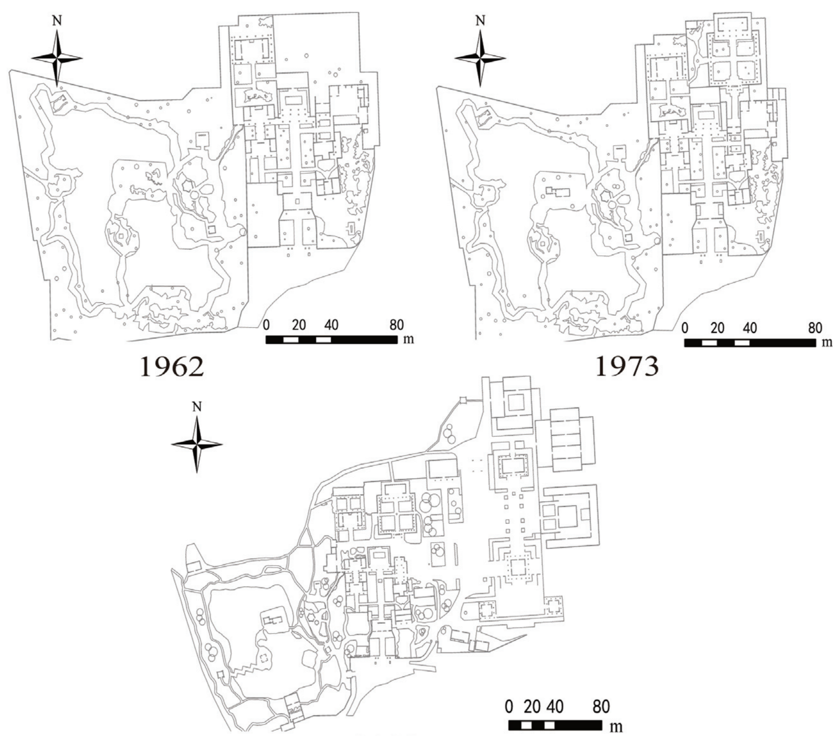

Figure 2. Two-dimensional maps of Daming Temple in 3 different periods for VGA analysis.

In the VGA model, the temple heritage space is transformed into a 2D grid system of 0.8×0.8 m for the width of 0.8 m, approximately the width of a person's shoulder. The amounts of elements in the operation are simplified within the range that is acceptable for computation. 'Accessible' areas in this study are identified as those areas open to the public and can be visited freely most of the time, referring to the information provided by the Cultural Publicity Department of the Daming Temple, Jiangsu Province, and the in situ survey. In addition, spatial elements are processed with the method explained in Table 1. The drawing principle of elements is considered according to the significance of impacts on the viewshed model per se by elements (Table 1).

Table 1. Principles for drawing spatial elements in the VGA model.

Spatial Elements	Effects on Circulation of Visitors (Yes/No)	Knee-Level Model (Draw/Not Draw)	Effects on the Viewshed (Yes/No)	Eye-Level Model (Draw/ Not Draw)	Detailed Explanations
Wall	Y	Draw	Y	Draw	Only draw those walls and pavilions that block the paths and viewsheds.
Pavilion	Y	Draw	Y	Draw	
Rockery	Y	Draw	Y	Draw	Only draw those rockeries with heights ≥ 1.6 m.
Arbor	N	Not draw	Y	Draw	
Window	Y	Draw	N	Not draw	Only draw those windows and doors that can be accessed or walked through.
Door/Gate	N	Not draw	N	Not draw	
Shrub	N	Not draw	N	Not draw	Isolate-planted small vegetation is neglected.
Lawn	Y	Draw	N	Not draw	
Waterscape	Y	Draw	N	Not draw	

As for the ASA model, it is commonly idealized that visitors often act as 'embodiment' in spaces with various forms, which leads to their diverse behavioral patterns of pathfinding [29]. The 'revised' distance that fits the perception pattern of the visitor is defined as the 'psychologically shortest expected path', which represents the psychologically expected distance perception of the visitors in spatial systems. It is noticed that visitors are often willing to walk through paths with the shortest Euclidean distance in the barrier-free spaces; otherwise, once visitors perceive the fact that there are spatial barriers (e.g., stone steps) exist in the space ahead, their 'psychologically minimum expected distance' will firmly increase. Therefore, visitors' sensory perception should be considered for the ASA model. A special modeling approach is used for the wide area of the East District in this study.

Some key drawing principles in the practical modeling process are applied (Figure 3) to enable the model to reflect visitors' psychological costs. Firstly, considering those areas with stairs, the polyline segments with angle change are used to represent the psychological distance expectation. Secondly, for the distinctive spatial differences between the newly built East District and other spaces, the widths of those new-built spaces are relatively larger; thus, the visitors' behavioral preferences are often affected by seeking paths with the shortest Euclidean distance when then walking through the space. Thus, the square spaces are represented by diagonals.

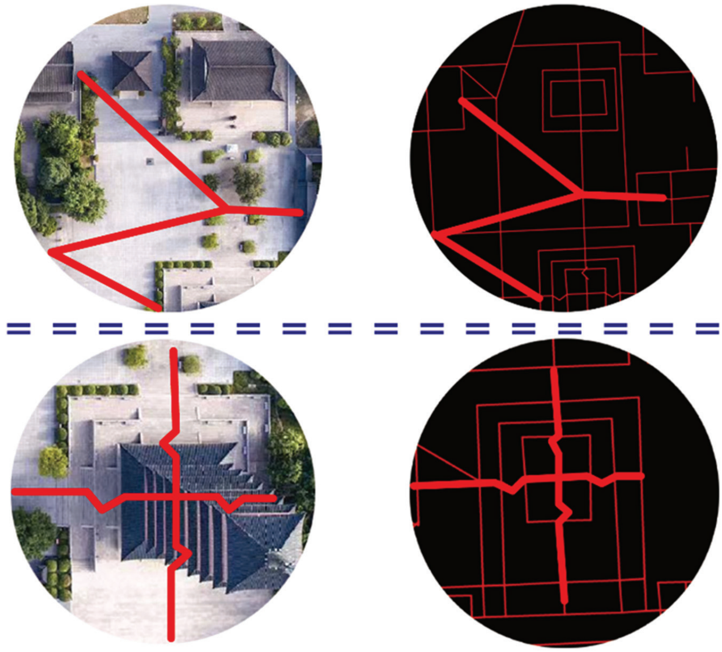

Figure 3. Detailed samples of key drawing principles in the ASA model.

3. Results

3.1. Changes in the Center of Spatial Configuration

Both the ASA and VGA models are used in this study to investigate the change in the center of the spatial configuration of the temple. The ASA model is based on the simplified accessibility network, while the VGA model is used to represent the coincidence and separation of the visual and accessible spatio–temporal structures.

In the VGA model, constructed using the software DepthMap 1.0, the MD values are visualized (Figure 4). As for the knee-level layer in 1962, the area with the highest 10% integration value is located in the Main Hall and its front area, while the area with the highest 10% integration value in the eye-level layer has a high similarity with those in the knee-level layers. In 1973, there was no obvious change in the integration value of each part of the space, although a new architecture, Jianzhen Memorial Hall, was built. The position of the center of the spatial configuration in the system does not change noticeably. In 2022, the area with the highest 10% accessibility is located in the wide area of the east side of the temple architecture, while the area with the lowest 10% accessibility is located in the West Garden. It can be seen that the Main Hall had a higher level of accessibility in the area before the construction of the East District. After the redesign and expansion of the East District, we observe that the center of spatial configuration was shifted to the eastern side, indicating that the topological priority of the Main Hall was gradually replaced by the East District. In 2022, the East District turned into a more accessible place eventually.

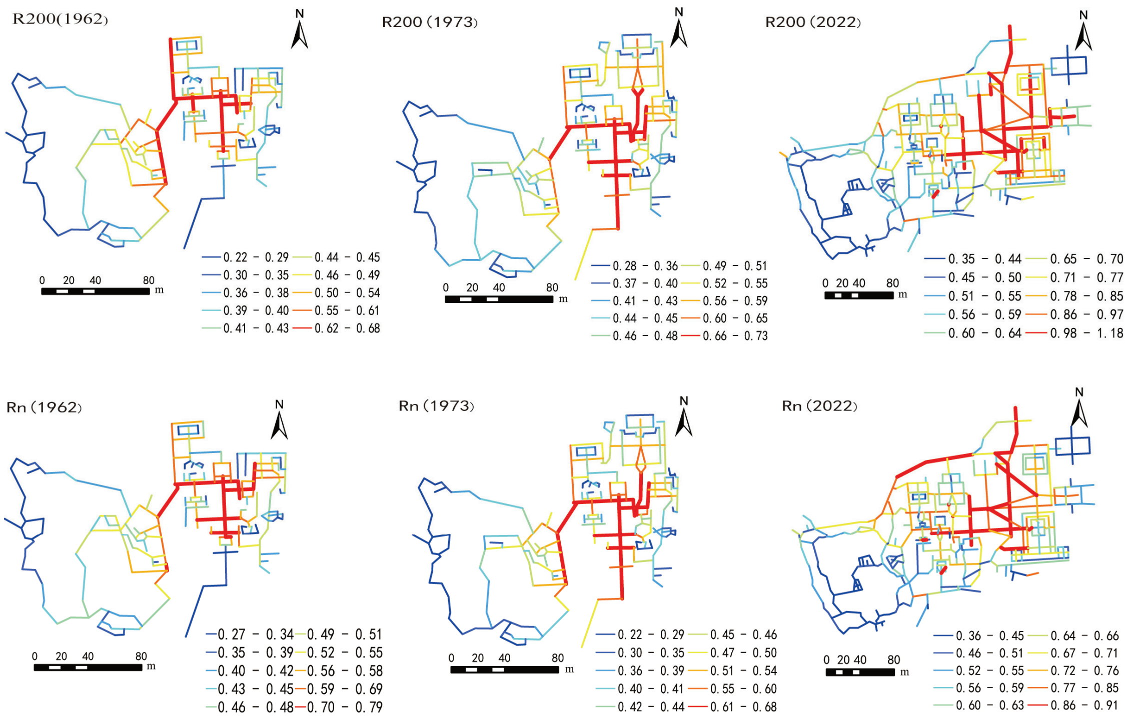

Figure 4. Visualized results of NAIN analysis in different periods.

In the ASA models, some key space syntax indices, e.g., integration, connectivity, and intelligibility, are believed to be competent for measuring the quality of space [30]. An ASA model is generated by the software DepthMap 1.0 (Figure 5), in which the center of accessibility is bolded for high-clarity visualization, and 200 m-radius integration and global integration are calculated, respectively. The values are visualized in reversed pseudocolor, i.e., reddish hue for lower values while bluish hue for higher values. Comparing the results by NAIN and VGA analysis, typical patterns of their spatial configuration are found. Some differences are noticeable. In 2022, the distribution of NAIN values presented that the higher-valued area is the path between Mahavira Hall and Qiling Pagoda, where the NAIN values of these sites are noticeably different from their surroundings. These phenomena above do not present any statistical inconformity with the findings in the VGA model.

The ASA model is further utilized in studying the variations of the center of the temple during internal spatio–temporal structural changes in chronological order. Considering the distribution of NACH in different periods (Figure 6), some phenomena are highlighted as follows. Similar to the evolution of the center of accessibility, the traversal center also conducted a process of centrality shift, transferring from east to west. The existing center of accessibility presented a lower influential effect in local spaces, whereas the original traversal center still maintains a high probability of being accessed by visitors. Although the space near Mahavira Hall has decreased accessibility, it still plays an important role in the local space of the circulation of visitors. Meanwhile, the center of the entire space also tends to transfer toward the East District.

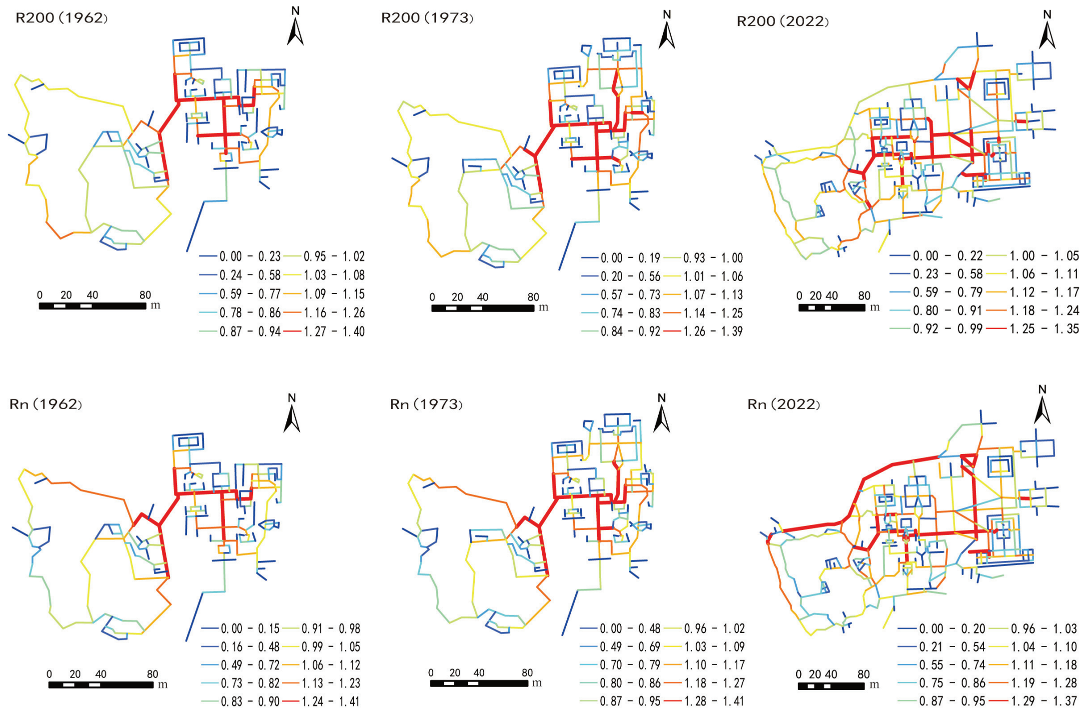

Figure 5. Visualized results of NACH analysis in different periods.

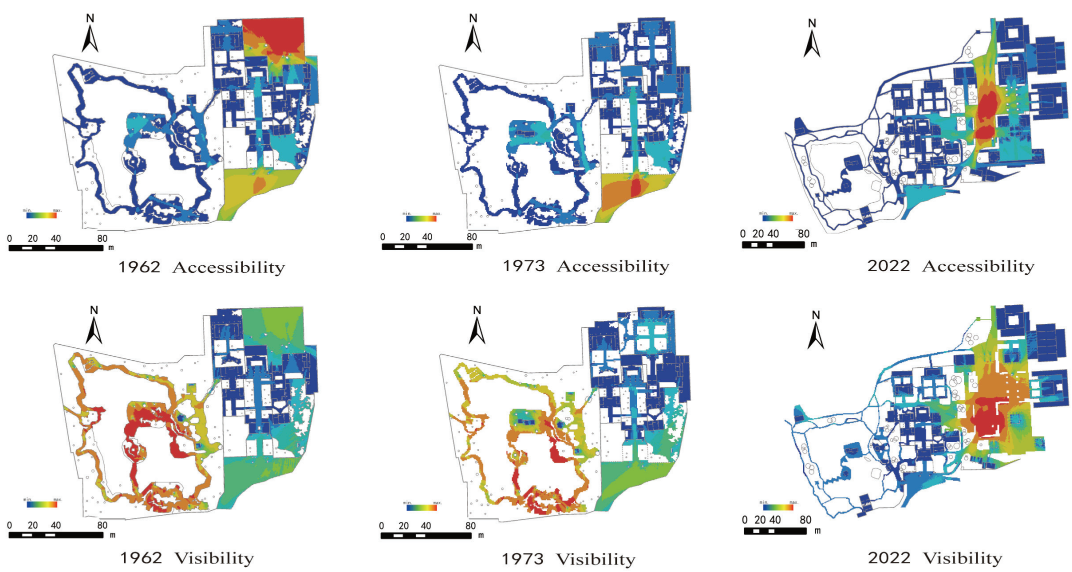

Figure 6. Distribution of connectivity in different periods.

3.2. *Changes in Interrelationships among Local Spaces*

We further explore the changes in the specific relationship of 'temple-residence-garden' in the process of spatio–temporal changes in the temple heritage to summarize some highlighted findings. A quantitative estimate of the MD values is calculated by Formula (1) given in Section 2.2. in the DepthMap software. In 1962, the MD values of the West Garden (5.25–17.67), Pingshan Hall (5.26–8.95), and the Main Hall (4.75–6.26) were lower than the average value of the global MD. The global influence effect of the West Garden is not significant, while the MD value of the West Garden fluctuates, which may indicate that variations in accessibility are noticeable in hierarchical orders [31]. The MD values of both knee level and eye level in 1973 were lower than those observed in the 1962 model, but the hierarchical relationship of the topological space system did not occur in qualitative variations.

For the knee-level layer in 2022, the MD value of the Main Hall (4.20–5.51) approximates the MD of the global spatial system (4.23–5.42). The accessibility of the Main Hall is decreasing year by year; otherwise, the MD value of Pingshan Hall (4.93–7.78) is still remarkably higher than that of the Main Hall. The MD value of the West Garden (4.33–16.84) is higher than that of the global MD, indicating that the hierarchical order of accessibility in the West Garden is weakened. At eye level, the accessibility of the West Garden and Pingshan Hall is also approximate, and the accessibility of religious space and architecture (i.e., the Main Hall) is higher than that of these areas dominated by semi-natural landscapes (i.e., the West Garden and Pingshan Hall).

3.3. Changes in Spatial Connectivity

The ‘connectivity’ index in the VGA model can reflect visitors’ recognition of the space. By the analysis of the eye-level connectivity in 1962 (Figure 6), values of the mean con. of Mahavira Hall (502.59), Pingshan Hall (228.56), and Guling Hall are calculated, whereas the mean con. of The West Garden (3570.83) is much higher than the global average value. As for the knee-level connectivity, the mean con. values of the West Garden (247.08) were less different from those of other architectures in 1962. In 2022, both knee-level and eye-level connectivity of the new-built East District were noticeably higher than elsewhere; however, the relationship between existing spaces has not changed. Compared with the changes in spatial connectivity among the three periods, the perception of the spaces surrounding the architecture and garden was very close before the redesign and reconstruction of the East District, while the visual perception of the architecture is relatively closed. The visual space permeability of the West Garden is the highest, with visions of higher openness.

3.4. Changes in Spatial Intelligibility

After the redesign and construction of the East District since the 2000s, the form and configuration of the global space have observed to undergone certain changes, which may affect the activities of visitors. In the space syntax theory, ‘intelligibility’ is a parameter for the evaluation of difficulties the visitor will suffer in understanding geographical positions in the global space, and the complexity of spaces can be calculated based on the MD value of the local and global spaces [32]. Results attained in the former steps are used for regressive calculation of the intelligibility, with connectivity as the x-variable and NAIN as the y-variable (Table 2). By a Python program developed with the package matplotlib for quantitative statistics, the goodness-of-fit (R^2) parameter is calculated. R^2 has a value range of [0–1]. The closer R^2 to 1, the higher the intelligibility, and vice versa. It is seen that the global ‘intelligibility’ values are consistently low, which indicates that the probability of getting lost in the space is higher for visitors, which can be explained by its unique ‘temple–residence–garden’ spatial structure.

Table 2. Values of intelligibility in different periods.

Indices	Term	NAIN (1962)	NAIN (1973)	NAIN (2022)
Intelligibility R400	Goodness of fit (R^2)	0.258	0.252	0.230
	Significance	0.000	0.000	0.000

Quantitative estimation of the MD values in the VGA model is calculated by Formula (1) in the DepthMap software (Table 3). The higher the MD value, the higher the average number of turns it would take visitors to pass through the space; in other words, the space is relatively more complex. We observed that the visual-spatial structure of the temple heritage in different periods keeps relatively simple. On average, at least two turns of the visitor's movement can enable them to take a global visual perception of almost all spaces in the study site. The reason for changes in visitors' paths is explained as follows. The structure of accessible space distribution is found to be of high complexity, requiring visitors to make at least six turns to pass through the heritage space in both 1962 and 1973. However, after the reconstruction of the East District, the scale of the Daming Temple increased. There are at least four turns needed for visitors to pass through the temple in 2022. making it easier for visitors to perceive the global structure of the space, which is likely to be effective for the revitalization of the temple as well as the development of tourism [33]. Simultaneously, with the expansion of the East District, the scale of the temple has been increased, making it more efficient and encouraging visitors to perceive the global topological structure of attractive spaces. Therefore, it has a certain positive significance for the heritage revitalization and tourism development of the temple.

Table 3. Values of global MD in different periods.

Year	Area of All Architectures (m^2)	Area of the West Garden (m^2)	Total Area (m^2)	MD Value (Eye Level/Knee Level)
1962	11,431	17,415	28,846	7.54/3.55
1973	11,861	17,415	29,276	7.46/3.47
2022	28,310	18,713	47,023	5.23/2.36

4. Discussion

4.1. Explanations of Changes in the Spatial Structure

From the statistics, we found that the centrality of the spatial structure of the temple was relatively stable, whereas the topological structure has been changing greatly since the 1990s, during which the center of accessibility has been gradually transferred toward the East District. In addition, decreasing MD value presents the development of tourism planning and construction of the temple. Otherwise, Mahavira Hall always remains its spatial–topological priority among the global spaces, which indicates that the religious functionalities of the temple have presented a 'guidance' effect on spatial–topological transformations [34]. The religious-functional architecture in the existing spaces of the temple during the three periods have shown their distinguished significant influences on the spatial form, while Pingshan Hall and the West Garden present low spatial influential effects but a higher level of integration.

Moreover, the traditional spatial layout of the existing scenic sites of the temple is appropriately well-preserved, for sustainable strategies for building heritage conservation have been applied, i.e., protecting the ancient temple building and expanding the new-built scenic areas simultaneously. The spatio–temporal changes in the spatial system are typical temporal processes that offer quantitative records of the dynamic developments of the temple [35]. These records are of help for those individual visitors to perceive the historical memory of the space, which is believed to be effective for the reactivation of cultural heritage.

4.2. Explanations of Changes in Temporal–Spatial Connectivity

As for the spatial design of the Daming Temple in different periods, spaces with different characteristics were rearranged several times, which contributed to the creation of complex spaces with a deep sense of closure-openness interrelationships [36]. These interrelationships transform the spaces surrounding the architecture into more closed and enclosed forms, and the spaces surrounding the garden have maintained a high degree of openness. These phenomena can be explained as follows:

In ancient times, the small-scale architecture in temples was designed for Zen meditation by monks, and the huts surrounding the garden were designed for the lord of the manor to entertain guests, i.e., writers and painters. Therefore, the spaces around the small architecture and the huts tend to be more 'dynamic' in the topological network, facilitating activities such as literary gatherings. In contrast, the West Garden was designed as an attractive space to enjoy the landscape, so the garden is more 'static'. The contradictions between these spaces highlight the functional differences between architectural and garden spaces [37]. Furthermore, the temporal connectivity at both eye and knee level in the West Garden is also confirmed to be quite different, which is believed to be induced by the design of the unique spatial structure and abundant landscaping elements. These design techniques have also been shown to be effective in creating mysterious aesthetic experiences for visitors, as noted in a similar study [38].

4.3. Explanations of Spatial Changes in Specific Scenic Areas

Although the center of spatial configuration has constantly been shifting, it was found that the original center of accessibility with higher MD values was constantly located around Mahavira Hall. As a result of this phenomenon, the global spatial structure and geographical features were well understood by visitors, which eased their pathfinding difficulties even in extremely complex spatial systems [39]. The spatial design methods used in Jianzhen Memorial Hall and Baoben Hall (Figure 7) have proven to be dramatically effective in increasing the visitors' visual perceptions. When visitors walk around the center of accessibility, they can easily find Jianzhen Memorial Hall. At the same time, the pavilion at the main entrance blocks visitors' view into the spaces. These spatial design methods can skilfully guide visitors to perceive the spatial structure and precept the excessive 'in-between' senses along their routes.

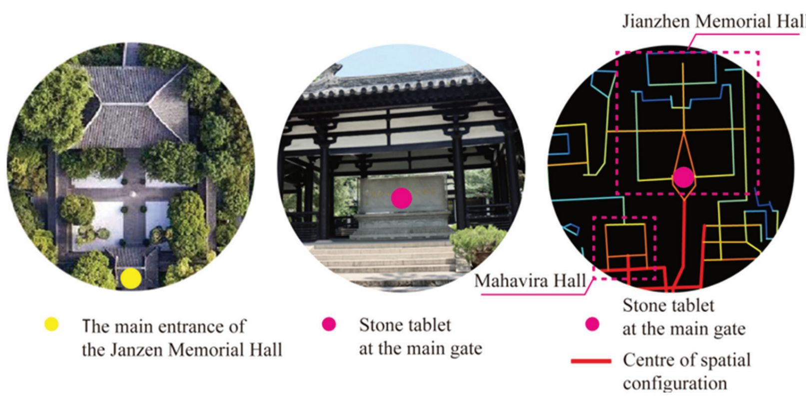

Figure 7. Detailed design of Jianzhen Memorial Hall.

In terms of the practical design, the detailed design of the East Garden makes flexible use of in situ topographic conditions. The new-built East District has not affected the connectivity of the temple; otherwise, the spatial enclosure of the existing and new-built scenic sites in the space is remarkably dynamic.

The perception of physical activity areas and visual perception of knee-level and eye-level accessibility in the West Garden during the three periods are quite different, which presented the 'visual perception' characteristics of temple gardens. In addition, the existing temple garden space has a complex structure that allows visitors to perceive the unique and profound spatial structure.

4.4. Further Discussions

Further discussions of this study are concluded as follows. Among them, several comparisons between other space-syntax-based projects and this study are present, which should be noticed for other homogeneous studies in the future.

(1) The study adapts the methodological integration of two sets of space syntax models, i.e., the ASA and the VGA model. It is indicated that both models can be used simultaneously to better express the internal temporal–spatial characteristics of ancient temple garden design. However, the efficient framework and workflows in real-time modeling environments have not been developed for these methodologies, which is potential for further studies.
(2) The study tried to expand the scale of spatial studies by the quantitative approach, and some useful applications of space syntax have been applied to the typical ancient temples. However, the case study in this research mainly focuses on horizontal spatial relationships among building and landscape elements, while vertical temporal relationships and spatial interaction [40] have not been abundantly considered, which has the potential to be improved.
(3) The visualization in this study illustrates how the design of the building space enables visitors to clarify the complex structure of the space through the temporal–spatial center of connectivity and global intelligibility. Otherwise, some other indices may be developed for more specific estimations in the future.
(4) Although some conservative opinions believe that only a limited number of fragmented spaces can be redesigned to surround the existing historical buildings, recent studies believe that the redesign, reactivation, and redevelopment project of historical and cultural spaces should be conducted considering the overall spatio–temporal space, as mentioned in similar studies [41,42]. In the process of spatial redesign, reconstruction, and reactivation of the temple, conservation, and development are not in a dichotomy; otherwise, there is a connection between existing and new-built spaces, which often reveals profound spatio–temporal characteristics of the space. Thus, related professional scholars of urban design, landscape architecture, environmental design, geography, etc., should further study the internal spatial characteristics of spaces in the future.

5. Conclusions

This study aims to elucidate the spatio–temporal characteristics of a typical ancient temple in different historical periods through two spatial syntax models. The causal mechanisms between spatial design and spatial configuration are revealed quantitatively. It is convinced that the original hierarchical relationships among the temple buildings remained almost unchanged during the three periods. After the redesign and reconstruction, the centrality of the spatial composition of the temple has been shifting to the east, while the topological characteristics of some specific spaces have dramatically increased. Different local spatial functionalities are proved to be well arranged in the developments of the temple's construction, which creates an aesthetic experience for visitors through the closure-openness contrast in both eye level and knee level. The previously existing center of spatial configuration has been extended to the other local spaces, allowing visitors to easily comprehend the global spatial configuration. We found that the spatio–temporal changes had an impact on visitors' itineraries in the temple heritage. Overall, the research provides theoretical foundations and suggestions for sustainable conservation, redesign, reactivation, and management of typical temple spaces, while further relative studies can be conducted to improve the applicability of the spatial syntax models in further studies.

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heritage

Article

A Bridge with No Name: The Controversial Resignificance of Urban Architectural Heritage from a Gender Perspective in Cuenca (Ecuador)

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Abstract: Urban architectural heritage and its social manifestations are immersed in dynamics beyond their origin and conservation vision. Contemporary society reinterprets, reconfigures and resignifies it according to its own logics of empowerment. In this context, this article addresses the case of a bridge in the Historic Center of Cuenca (Ecuador) known by the names of Mariano Moreno Bridge, La Escalinata Bridge or Vivas Nos Queremos Bridge. It describes its patrimonial situation in terms of its values and its relationship with gender. Because of its social implications, this study is divided into two parts: a bibliographic analysis of the historical evolution of the monument, followed by a discussion of its heritage status, and the presentation of the design, validation and application of a qualitative tool to determine the values associated with the property. This tool is used in a focus group of actors to analyze the feminist activism developed on the bridge between 2020 and 2022. This research shows how cultural heritage can be known, valued and used from an inclusive perspective and how public space can be subject to processes of resignification. This bridge became a non-place, a forgotten and a meaningless site. However, due to the struggle for the vindication of women's rights and freedom of expression, it has taken on a new meaning, becoming an integral part of the contemporary collective imaginary, regardless of its uncertain nomenclature.

Keywords: Mariano Moreno; Vivas Nos Queremos; bridge; urban heritage; resignification; cultural value

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1. Introduction

The construction of an urban image following the demands of international tourism has defined the success of Cuenca [1] as a historic settlement. As a result, its architecture is part of the refined aesthetic that has historically excluded rural, popular, indigenous, queer and controversial manifestations in multiple Latin American cases. Likewise, gentrification processes, influenced by a strong foreign presence, reproduce colonial social relations and marginalize popular [2] and informal economic activities.

There is a scenario where the middle classes are positioned with higher incomes than the local ones, who, attracted by historical urbanism, displaced the original groups, resulting in an increasing impact on the use and meaning of urban areas [2]. It is not confined to Cuenca (Ecuador) as a phenomenon; intermediate and small cities are also experiencing it. In addition, disputes over public space, gender, identity and class have a long history, and certain passages stand out. The oldest dates back to the colonial establishment when it imposed an urban order characterized by social and spatial segregation [3–6], along with the dispossession of the collective.

By 1980, Cuenca's social elite was shocked by the popular and indigenous appropriation of symbolic urban spaces [7,8]. Approximately a decade later, commercial and architectural elites initiated a "reconquest" based on large investments, which displaced lower-income residents [2]. Nowadays, these spaces resist intertwining formal and informal activities, making it increasingly difficult to separate, forget and purify [9]. There is no denying that Cuenca, like other Latin American cities, is increasingly problematic for local authorities [2], as popular uses of public space, leisure activities and planning ideals clash with the nostalgia of elites. Taking this into account, Ecuador's Organic Law of Culture (Ley Orgánica de Cultura—LOC, in Spanish), which defines cultural heritage as the "dynamic, integrating, representative collection of goods and social practices, which people create, maintain, transmit, and recognize as cultural heritage, communities, communes, nationalities, collectives and cultural organizations" [10], warns against such events.

To address the case of contemporary processes of spatial appropriation and heritage resignification, this research analyzes Puente Mariano Moreno, Puente de La Escalinata or Puente Vivas Nos Queremos, a symbol of urbanization during the twentieth century and a progressive icon for El Ejido area. We propose an analytical and reflexive approach from a heritage, historical and feminist perspective. Due to the scarcity of similar studies in both the city and the country, this position is of particular interest. On the contrary, there is a predominance of historicist [11,12], urban [13–15], architectural [16,17], anthropological [18,19], archaeological [20], mobility [21,22], participatory management [23,24], heritage management and public policy [25–27], and tourism [28–30] studies. In addition, studies related to the right to the city [31,32] have gained relevance in challenging the notion of the historic city.

Consequently, this work contributes to the understanding of contemporary phenomena, including female empowerment and freedom of expression from unauthorized voices, as well as cultural heritage, which is becoming increasingly important for its preservation, exercise of rights and quality of life.

2. Cultural Heritage: Conservation Visions and Orientations

In the Historical Center of Cuenca (Centro Histórico de Cuenca—CHC, in Spanish), the concept of regeneration of public space has been adapted as a form of "cleaning" social practices. This institutionalized process has displaced, relegated or forgotten actors, conditions, motivations and more, ultimately, cultural patrimony itself [33]. For Navas and Torres [34], it has been a strategy to strengthen the image of the heritage city as a distinctive brand and to adapt the urban policy to real estate and tourism demand. Therefore, local policies regarding public space use and occupation have been designed to promote tourists rather than citizens. Furthermore, despite institutional attempts to eradicate them, citizens' social use of cultural heritage has survived as a historical legacy, thus reaffirming their right to the city through the process of appropriation [34].

As part of its urban-architectural rehabilitation program framed in plans and projects initially situated around the Tomebamba River [35], the municipal administration created the El Barranco Foundation in 2004 to provide technical assistance in the recovery of public space [36]. As one of the most prominent advocates for traffic calming, this entity is recognized as an obstacle to securing higher commercial and residential rents for historic properties [2]. Several interventions to recover public space have been made since 2008. The most iconic are the modernized squares Cívica, Hermano Miguel, del Rollo, de las Secretas, La Mercedes, San Francisco and del Otorongo (Figure 1).

Figure 1. Location of public space according to the type of intervention in the Historical Center of Cuenca. Own elaboration (2022).

In these cases, the hygienist orientation eliminated the old uses and the displacement of its users, which weakened the social memory and the possibilities of coexistence [31]. Conversely, more conservative interventions have been shown to increase them (Figure 1), such as those in Plaza de San Sebastián, Plaza de San Blas and even Parque Calderón. The Plaza de las Flores, adjacent to the Monastery of El Carmen de la Asunción, is a perfect example of this dichotomy. A series of interventions were conducted between the modernized and conservative sectors due to the widespread rejection of the former and the need to renovate the latter.

On the other hand, Eljuri [18] argues that female occupations in CHC squares are strongly associated with craftsmanship from the perspective of Intangible Cultural Heritage (ICH). In these markets, an asymmetrical male-production and female-commercialization relationship turned many market squares into essentially feminine spaces; however, female workers have been doubly excluded from the hegemonic narratives. Despite these conditions, contemporary urban design and intervention have been limited to reproducing historical strategies, excluding the protagonists and eradicating their features. San Francisco Square, for instance, has been the subject of repeated rehabilitation initiatives since 2006, but these projects have been dismissed by not considering the links between actors and uses. Only in 2017 did the intervention become concrete. The lack of vision regarding intangible heritage values and social use was apparently resolved. However, in practice, historical users are excluded [18], and gender approaches are absent (Figure 2).

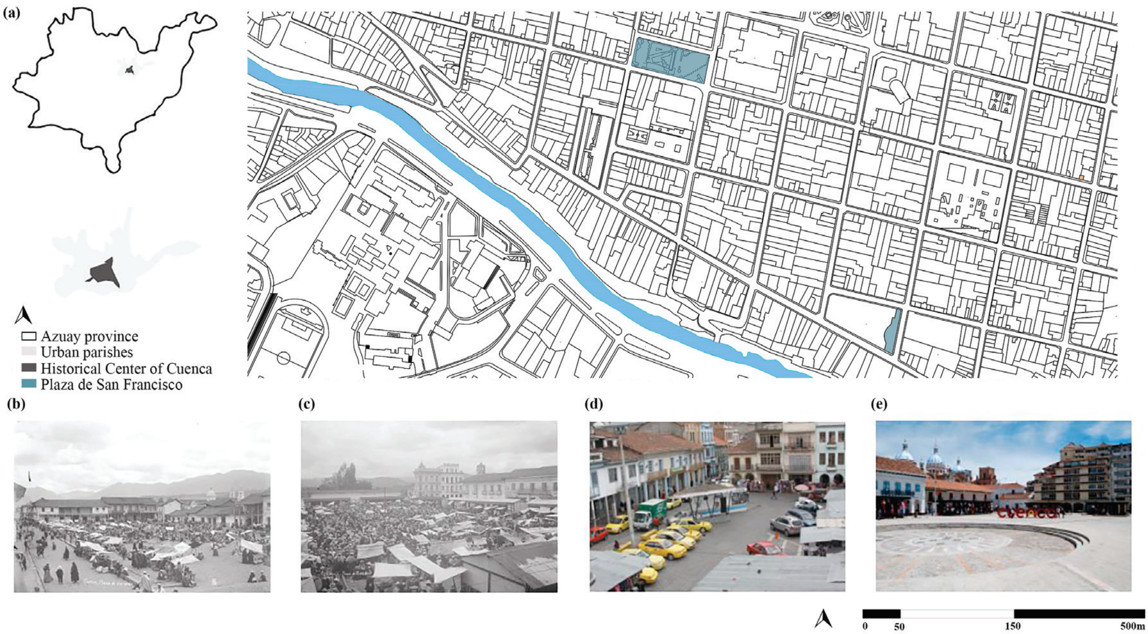


Figure 2. The case of the Plaza de San Francisco. (**a**) Case study location in the Historic Center of Cuenca. (**b**) Cuenca, San Francisco (Cod. 14096). Fondo Nacional de Fotografía (1920–1930); (**c**) Cuenca, San Francisco (Cod. 14097). Fondo Nacional de Fotografía (1920–1926); (**d**) San Francisco prior to urban-architectural interventions. CPM Project, University of Cuenca (2015); (**e**) San Francisco after urban-architectural interventions (2021). Own elaboration (2022).

Although there has been a permanent interest in recovering public heritage spaces, citizen participation dynamics are rarely incorporated. Alternatively, the regulations and instruments are built and applied within the public administration structure. In this way, disruptive, emergent, spontaneous or unplanned manifestations are presented as an attack on the space's quality and the occupants' well-being. Even though social relevance is recognized in the occupation and transformation of space, little is known about the limitations (or possibilities) that certain historical, social and political factors may represent [31].

While physical interventions bring indisputable improvements and UNESCO World Heritage status such as that of CHC can be an important stimulus to urban economies [37], they are insufficient to provide livelihoods for all residents or, at least, not for the majority [38], which often exacerbates spatial injustices. Thus, even though the intervention might affect economic dynamics, there are symbolic implications, perhaps even greater than and appropriate for the immaterial dimension of cultural heritage, and by doing so, the "improvements" end up reproducing colonialism [2].

In the end, the recovery of heritage public space has been a function of power groups, including the public administration, being able to distinguish between appropriate and inappropriate uses [37,39]. Within the framework of the latter, the present study aims to demonstrate the forcefulness with which their presence resignifies the heritage asset.

3. Historical Reality: Puente Mariano Moreno, Puente de La Escalinata or Puente Vivas Nos Queremos?

The construction of Puente Mariano Moreno began in 1930 under the direction of Sergio Ojuela, within the framework of a relevant public works program. In the same manner, as a small rural parish of Gualaceo, a city near Cuenca, this bridge took the name of Mariano

Moreno—an illustrious patriot and promoter of public works in the region [40]—who was Governor of Azuay for two occasions (1859 and 1887) [41]. Moreover, it took ten years for the construction to be completed and another ten years for the opening [42] (Figure 3).

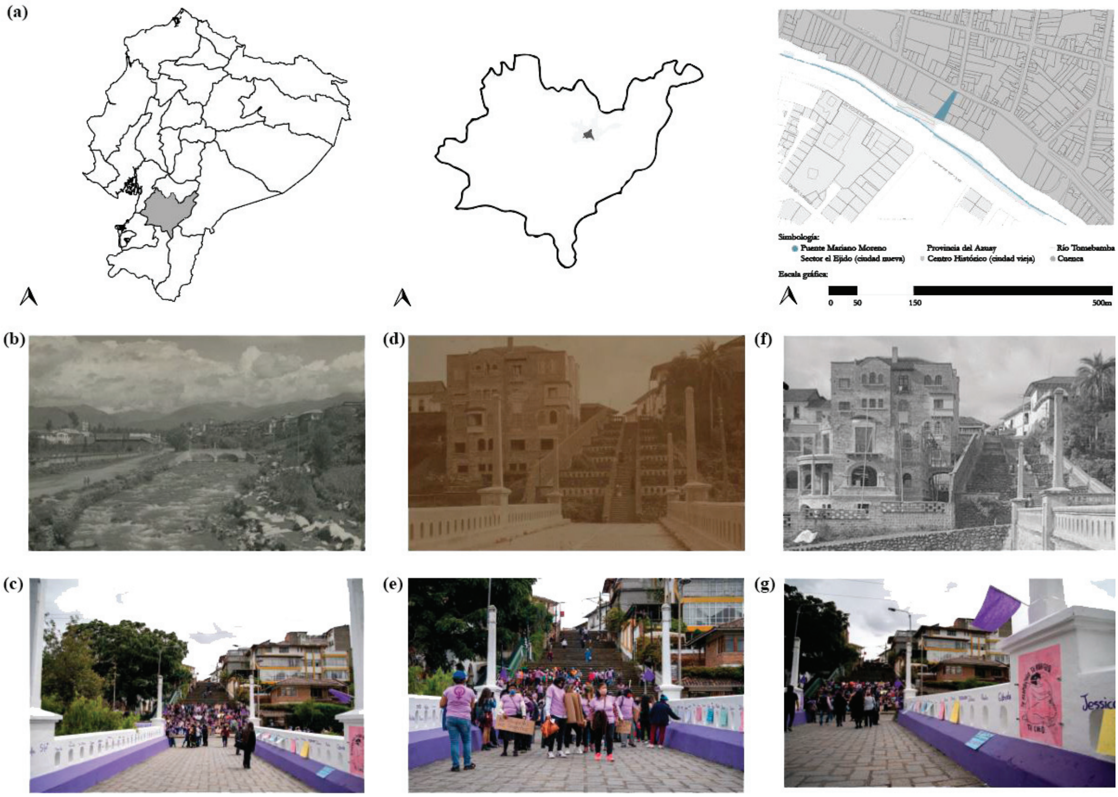


Figure 3. An overview of the study case. (**a**) Geographical location. Own elaboration (2022); (**b**) Tomebamba River and El Barranco (Cod. 18606). Source: Fondo Nacional de Fotografía. Museo Pumapungo (1943); (**c**) Current use of the Puente Mariano Moreno by feminist organizations; (**d**) Mariano Moreno Bridge (Cod. 17049). Source: Fondo Nacional de Fotografía. Museo Pumapungo (1943); (**e**) Current use of the Puente Mariano Moreno by feminist organizations. Source: Authors (2022).; (**f**) Stereoscopic view of the Tomebamba River (Cod. 12890). Source: Fondo Nacional de Fotografía. Serrano, M.J. (1940–1950); (**g**) Current use of Puente Mariano Moreno by feminist organizations. Source: Authors (2022). Own elaboration (2022).

The need for such infrastructure arose from the growth of the El Ejido area. The Public Works Board of Azuay (La Junta de Obras Públicas del Azuay) stimulated the construction of La Escalinata Francisco Sojos Jaramillo and the replacement of the modest Tarqui bridge [41] as a recent means of accessing the current Historical Center, Paseo Tres de Noviembre and boulevard 12 de Abril, which precedes an avenue of the same name (Figure 3). Since then, despite the predominance of vehicles, it has been mainly used by pedestrians [43] due to the section's narrowness and the area's daily dynamics. The most representative activities were the washing of clothes, the drying of hats, and agriculture, which intensified progressively and was confirmed as an effective means of communication between river banks only in 1940. Sports activities would confirm this link from the 1980s onwards with the launch of Olympic walking.

There have been many historical events associated with the bridge; it survived the Tomebamba river flood, which destroyed the Todos Santos (Puente Roto) and El Vergel [42] bridges, likely due to its quality materials and execution, as well as being part of Cuenca's First Regulatory Plan in the late 19th century. The bridge has two slightly lowered arches with two lanes framed by plinths, rectangular columns and luminaires; it was constructed of boulders, brick and lime. These materials are particularly visible on the pavement and on the top surface, where the starts and supports are also highlighted, as well as the thick parapet with an oval-shaped balustrade.

In terms of urban infrastructure, the bridge marks the transition from one zone to another and distinguishes the old city from the new one (Figure 3). The northern area is commercial and administrative; the southern area is commercial, entertainment, and residential [42]. In addition to being the natural border, El Barranco is also the Tomebamba River corridor and contains buildings that have been adapting to the topography, demonstrating particular conformity to the natural landscape [44]. The area is currently primarily commercial; touristic; and to a lesser extent, residential. As the bridge is integrated into the landscape, cultural events such as craft gatherings, festivals and fairs are generally held on civic dates.

This scenario emphasizes the importance of cultural heritage, public space and social manifestations. The area's transformation has favored it since 2004, which was accentuated by the 2013 intervention of the Parque de la Madre. However, it was only after events promoted by the local feminist movement that it regained visibility between August 2020 and March 2021. The #MeToo or La Marea Verde [45] took the site to protest violence against girls and women in cases that shocked the local society [1]. On 11 September 2020, messages in support of abortion legalization were posted. However, the action provoked a heated discussion and re-establishing of its previous aesthetics. Similar situations have occurred with the participation of public forces on a permanent basis, evidencing the contrasts of local society. At the same time, spaces such as the bridge are part of the city's living heritage, where new generations can appropriate and generate meanings [46].

The National Institute of Cultural Heritage [47] maintains a heritage asset file; however, it does not provide a comprehensive interpretation of heritage values. Furthermore, the document does not define limitations regarding physical changes observed or possible since it is not an effective conservation instrument. Moreover, there is no explicit inventory or record from the local administration in this context. However, based on the year of its construction and the literal law of art, 54 of the LOC [10], it falls into the category of national heritage. In 1982, the Historic Center was declared a national heritage site, and in 1999, it was designated as one of a set of World Heritage Sites: therefore, the heritage status of this building is legally defined, because it is one of a group of buildings constructed before 1940.

Aside from the administrative and regulatory perspective, also relevant is the bridge as a social asset. In recognition of the International Day for Non-violence against Women, the bridge was symbolically renamed Puente Vivas Nos Queremos [1] by adding a commemorative plaque [48]. This aspect is distinct from the conventional meaning of heritage. Nonetheless, the conjuncture revives the asset's historical and symbolic value by bringing together groups and activities with subtle changes [49] that represent access, use and appropriation regardless of historical conventions such as urban nomenclature.

4. New Approach: Gender Perspective and Resignification

Cities can be understood as the union of social, economic and cultural factors specific to those who inhabit them, resulting in the construction of identity processes connected to space [50]. To understand the link between people and the world around them, one must consider their identity and three additional aspects: (1) the selfhood of the individual, (2) the group relationship, and (3) the understanding and acceptance of global changes [51]. In general, identity can represent people's idea of who they are, what the world is, and the security it provides them. This concept changes depending on the level of control over global logic and material security [52].

To resolve the uncertainty of a reality that can be inextricable, a certain search for identity originates in which the individual chooses cultural heritage. That resource can adapt to the rational and scientific concept of the world. At the same time, it does not represent an object that would produce subordination, keeping the essence of individuality based on autonomy. Therefore, cultural heritage is presented as a bridge to unite people with the past and, at the same time, guarantee them a future [53]; therefore, heritage assets are shown as a reflection of the passage of time; they become, unconsciously, instruments that lead people to feeling that they are part of a whole (Figure 4).

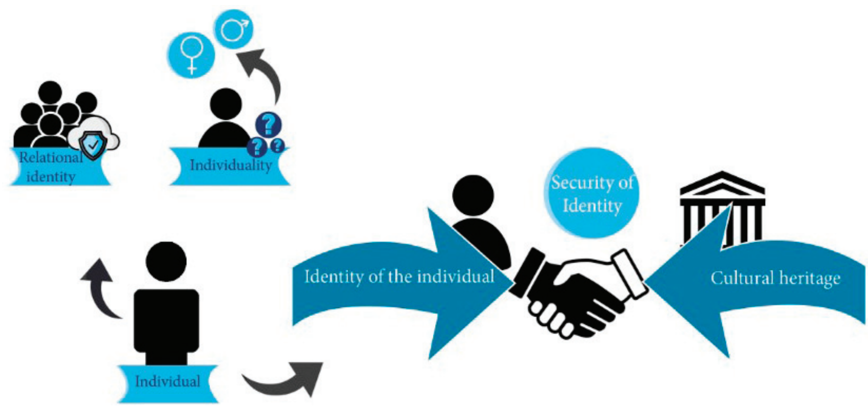


Figure 4. Identity relationship between individuals and cultural heritage. Source: [50–53]. Own elaboration (2022).

When speaking of cultural heritage as an element of identity, the social value should be emphasized as its raison d'être since it is the people who decide to protect and preserve it [54] or, failing that, to destroy and replace it. These facts explain the importance of the social–public spaces link as representatives of identity and well-being. In addition, the city-users' relationship generates urban and architectural impacts [55], and it is society's axis to understand its configuration, dynamics and transformation over time. To understand the socio-spatial relationship, identity development must be considered as a dynamic cultural and historical framework between the individual and the social [56].

In this sense, two determining groups stand out: (1) societies of low socio-economic complexity and (2) the individual human being. The former is characterized by relational identity and are complex systems of interpellations and recognitions [57] supported by the collectivity to feel certainty and stability towards that which they cannot control without differentiating between men and women. The latter becomes visible as work becomes more specialized; men become individualized, while women remain in the role of relational identity, which finally represents female gender identity. Unlike the security that permanence in relational identity generates, men's individualization provides evidence of changes and transformation as synonyms of productivity and development.

In this way, the identity conception has presented a clear relationship with aspects such as gender or race [58]. Female identity is a construction; however, the individualized and patriarchal context in which societies have developed has linked women to an expressive and affective role, limiting their instrumental role and, therefore, the fulfillment of various goals [59]. According to Marx, women are included in the group of oppressed people, also defined as "others"; they are part of minorities and disadvantaged collectives [60]. This derives from the telling of history from an androcentric perspective [61], which has relegated the female figure from representations with which people identify themselves at an individual as well as collective level.

In response, feminism emerges as a movement in search of real equality between sexes; it goes through several processes or waves that seek its achievement: the first from the recognition and struggle against the bureaucratic state, capitalism and the patriarchal family [62]; the second for the valuation of women as subjects at the institutional and cultural level, allowing them to participate in political, economic and social spheres [63]. The third deals with inequality between men and women and the lack of recognition of the female collective, and the fourth emphasizes the struggle of women against violence [64] escalating in recent decades [65]. The last two waves are of particular interest in terms of the processes of valuation and resignification of cultural heritage today, and in both cases, the revaluation of women is the starting point for new social construction.

However, it is also important to note that the Convention on the Elimination of All Forms of Discrimination against Women [66] establishes measures to limit actions based on the idea of inferiority–superiority of the sexes or stereotyped roles; however, traditional cultural practices are not considered a threat or do not contribute to discrimination against women. Entities such as UNESCO have worked on issues inherent to inclusion and equity, as well as on respect for the principle of non-discrimination in human groups in terms of gender. In this sense, it is appropriate to analyze how to redefine public spaces, social spaces par excellence, from a gender perspective and concerning cultural heritage to offer conservation scenarios as social dynamics have changed [67]. Particularly, the role of women in ICH contributes significantly; access and participation of expressions are determined by gender, and this is the ideal context for the shaping and transmitting roles and identities [68,69]. In addition, equality and non-discrimination are fundamental human rights; therefore, in ICH, we should not focus on the different gender roles but on preventing them from undermining the dignity and well-being of the actors [68].

For its part, from the socio-spatial relations, contemporaneity exposes several cases of potential resignification and positive impacts from the gender approach (Table 1), such as the case of the Plaza de la Constitución in Mexico City, whose strategic location allows for solving political, financial, administrative and urban problems. From this, the linking of political and social activities evidences a change in the use patterns [70]. Thanks to the 2008 intervention, the space improved; the inclusion of urban lighting elements guarantees free mobility for people with disabilities [71], deriving great success. In addition, it is currently influenced by gender and diversity in planning urban environments, improving safety and social integration. That is, it is consolidated as a versatile node for the changing activities of the year [72].

Another example is the Plaza de la República in Maracaibo, in which the political and civic use serves as an articulating axis for cultural and commemorative meetings, to which recreational activities and artistic performances are added [73]. This coupling is typical of the contemporary city, which adapts to globalization and replaces traditional activities. To achieve this, spaces and societies go through transitions that may or may not be successful; in the Venezuelan case, spatial transformation is a reference for the various activist and social groups that gather there [65]. Likewise, and as part of the understanding of the impact of gender in the urban environment, the Joan Miró Park in Barcelona has become a landmark for the meeting of feminist groups, despite the fact that the space does not consider any of their needs, the implementation of vegetation and public lighting has generated a safe environment and, therefore, greater accessibility [74,75].

In the previous context, Lugo et al. [76] evidenced the links in light of two questions: how do women and men participate in the conservation of cultural heritage in the community, and what is the importance of cultural heritage for territorial development with gender equity? Moreover, it is defined that women should be considered as social actors to vindicate their rights and create support networks that contribute to territorial development, not only to achieve social, economic and political equality. To this end, it is important to understand that the appropriation and shaping of urban spaces arise as consequences of individual and group identity relationships with their environment [77]. However, and although this relationship is logical, the urbanism of contemporary cities includes patriarchal orientations and privileges; there is a differentiation between men and women regarding the use of public space due to time and space restrictions [72], especially due to behavioral patterns assumed by each one, which produces gender inequalities and intersectionality [78].

Table 1. Analysis references Source: [71–73,75]. Own elaboration (2022).

Case Study	1. Plaza de la República (Maracaibo, Venezuela)	2. Plaza de la Constitución (Ciudad de México, México)	3. Parque Joen Miró (Barcelona, España)
Heritage Condition	The Law for the Protection and Defense of Cultural Heritage of Venezuela [3], in its General Register of Cultural Heritage, categorizes the square as a type of Material Asset or Tangible Cultural Heritage.	The Law of Cultural, Natural and Biocultural Heritage of Mexico City [4] defines this square as Material Cultural Heritage in the category of Architectural Cultural Heritage.	The Law 9/1993, of 30 September 1993, of the Catalan Cultural Heritage [5], defines the park as an Asset of Local Cultural Interest, with the category of Property Asset for its sculpture Dona i Ocell.
Conventional Use	Place of reference for social, cultural and civic events and protests.	It is used as a political and religious center and has been the site of notable events in Mexican history.	Museum; citizen guard; sports, cultural and educational activities.
Contemporary Use	Epicenter of civic events, festivities and protests. Popular action activities for the formulation of inclusive and gender laws.	Concentration site for social and cultural events. Activism for Afro-descendant women and youth training activities for political advocacy.	Training space for women and their bodies, breaking the canons of beauty, aesthetic stereotypes and health.
Temporal dynamics of use	The square is open 24 h a day. Every 5 July, the national independence is celebrated and takes on a symbolic character due to the tribute to the national identity and honoring the states that make up the Republic of Venezuela.	The square is open 24 h a day. It hosts ceremonies to honor and raise the flag on 24 February, 15 and 16 September, and 20 November, representative dates in Mexico.	The park is open from 10:00am. Accessibility is limited at night, so it closes at 23:00.
Feminist groups	La Araña Feminista Tinta Violeta Movimiento de Mujeres de Mérida Colectivo Josefa Joaquina Sánchez Colectivo Apacuana Mujeres por la Vida	Colectivo Palabras de Arena Ateneo Mexicano de Mujeres Frente Único Pro Derechos de la Mujer ONG Conectadas Mx	Democrática de la Mujer Association Federación de Organizaciones Feministas Unión para la Liberación de la Mujer Colectivo Feministas de Barcelona Organización Feminista Revolucionaria
Other minority groups	Workers Students Social protest groups Itinerant vendors Artist Artisans	Children Young people Men Women Elderly people	Social groups (sports clubs) LGBTIQ+ groups Climate change activist organization

In opposition, feminism from urbanism proposes that the design of public spaces complies with urban policies of social diversity and responds to the differentiated needs of individuals, promoting the gender dimension from a collective approach that improves the quality of life [79]. In fact, in the complexity of today's society, the conception and use of public space are immersed in a broad framework of demands, needs and aspirations, which become more complex when dealing with spaces of heritage character, such as the Puente Mariano Moreno, Puente de La Escalinata or Puente Vivas Nos Queremos.

5. Materials and Methods

This research is primarily qualitative, with a descriptive, explanatory and relational framework. Using the case study as a research technique is an effective strategy to analyze heritage assets such as Puente Mariano Moreno, Puente de La Escalinata or Puente Vivas Nos Queremos, as an iconic scenario of feminist activism in Cuenca (Ecuador), particularly between the years 2020 and 2022.

The research process designed and applied is compatible with formal scientific research and its rigor [80]; therefore, it allows for describing in breadth from historical and theoretical inputs that symbolic appropriation has occurred due to the lack of citizen meeting spaces and how the different feminist collectives affect the construction of meanings. According to Carrasco [81], it would be descriptive social research, whose objective is to expose the characteristics of the social phenomenon in a specific spatio-temporal context [82]. The first phase includes a general bibliographic analysis (object, referents and concepts), the reading of the monument through time and its heritage valuation derived from the regulations. The second phase designs, validates and applies a qualitative tool to determine the values associated with the asset according to a focus group made up of key actors from academia, public administration, feminist groups, professionals, neighbors and citizens in general (Figure 5).

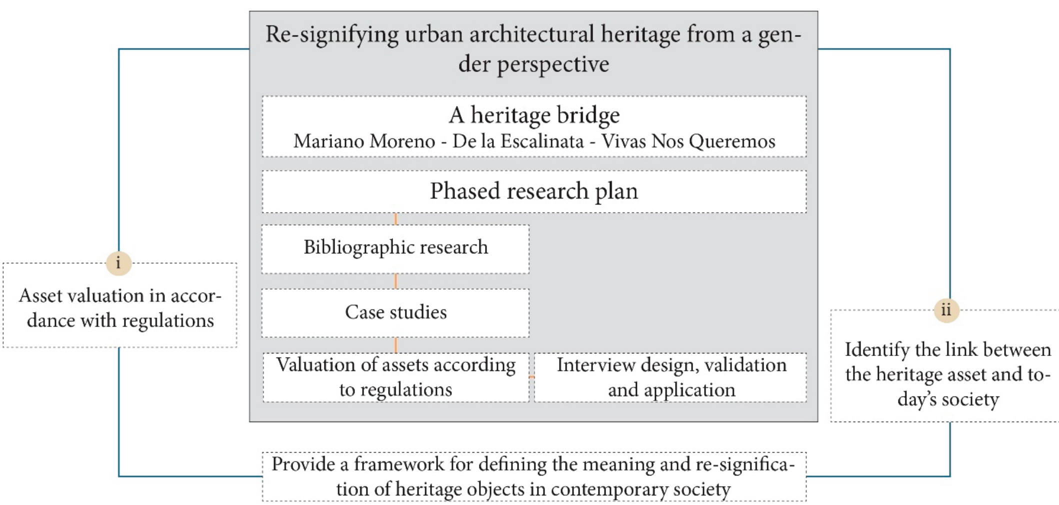


Figure 5. Research methodological structure towards urban heritage and gender perspective. Own elaboration (2022).

5.1. Phase 1

It develops the historical bibliographic research on the object of study and its context from local and national sources, without a specific time frame, since it seeks to characterize the object from its historical, architectural and heritage dimensions according to the authorized discourse [83,84]. In addition, three sub-phases are included; the first one is associated with the analysis of the scientific production, mainly from the last 5 years, employing a systematic search associated with the descriptors Puente Mariano Moreno, Puente Vivas Nos Queremos, Puente de La Escalinata, gender and cultural heritage, urban heritage, resignification and cultural value.

The second sub-phase relates similarities in terms of social problems: (a) Plaza de la República (Venezuela), (b) Plaza de la Constitución (Mexico) and (c) Parque Joan Miró (Spain). The selection is based on the determination of the incidence of the gender approach in public spaces, the activities they host and the contribution of feminism from urbanism in order to contrast the reality of appropriation and resignification. Based on the two previous sub-phases, the third phase carries out a heritage valuation exercise according to the criteria of the national regulations, applying four criteria and their different sub-criteria (Table 2). In the end, a degree of heritage protection [85] is established.

Table 2. Criteria for heritage valuation in public spaces [85]. Own elaboration (2022).

Heritage Assessment	
Criteria	Sub-criteria
Age	Period of construction
Physical–spatial conformation	Use and function
	Form and design
	Conservation state
	Authenticity and integrity
Contextual value	Urban generator or articulator
	Contribution to the urban image of the site
	Relationship with the urban-architectural environment
	Integration with the natural environment
Historical–testimonial–symbolism	Related to historical events
	Landmark or urban reference

The quantification of the criteria and sub-criteria fluctuates between scores of 1 and 5, with 1 being the lowest and 5 being the highest, according to the following: very high valuation range: 5; high: 4; medium: 3; low: 2; and very low: 1 [85]. Based on the partial scores, a sum is added to determine the degree of protection of the asset according to the following ranges: 0 to 15: no protection (i.e., the asset is not heritage property); 16 to 30: conditional protection; 31 to 45: partial protection; and 46 to 55, absolute protection. These processes make up the so-called Baremo Scale, an official protection instrument of a quantitative nature and qualitative basis.

5.2. Phase 2

Phase 2 seeks to broaden the view of the value and significance of the object of study. To operationalize this component, a general perception survey is applied and validated by means of expert judgment. In detail, experts in the areas of history, heritage architecture, urban planning, anthropology, politics and statistics evaluated the clarity, coherence, sufficiency and relevance of the instrument's content in two rounds. Based on this, the qualitative tool includes 16 questions (2 open and 14 closed) to measure the perception of the values associated with the asset. The closed questions use a Likert scale (between 1 and 5), where 1 is not at all relevant or irrelevant, 2 is scarcely relevant, 3 is not very relevant, 4 is relevant and 5 is very relevant. In addition, it is accompanied by a sub-scale that describes the variation in perception between positive (4 and 5), indifferent (3) and negative (1 and 2).

The survey was applied to a focus group of key actors from academia, public administration, feminist groups, professionals, neighbors and citizens in general. This group, made up of 11 members, is included within the ideal range recommended by Escobar and Bonilla

Jiménez [86], i.e., between 3 and 12 people. With this participation, the qualitative tool needs to include compliance with (1) free and informed consent, (2) confidentiality of the information, and (3) respect for the anonymity of the participants [87]. Likewise, in those cases in which the information of a social nature comes from documentary sources, as in Phase 1, the principles of situated ethics from qualitative social research are considered, including how sensitive accounts should be treated to ensure respect for the integrity and dignity of people, and not to threaten the social welfare or the rights of communities [88].

Between the two phases, it is possible to expose the framework of the meaning of the object of study from different edges, with the vision of building the heritage–gender relationship as a determinant of conservation in the contemporary city.

6. Results and Discussion

Spaces with a deep-rooted social memory and a strong sense of identity and belonging foster interactions and social organization. These two behaviors are accentuated in those connective assets and with conditions of centrality [31], as is the case of a bridge. In Puente Mariano Moreno, Puente de la Escalinata or Puente Vivas Nos Queremos, the dispute between the traditional dynamics of the use and occupation in relation to those disruptive ones typical of contemporary society has been framed. In the latter, a group of women express a political stance that questions the established codes of coexistence, female behavior, and traditional ways of valuing cultural heritage. In the words of Lefebvre [89], this is a positive appropriation that includes a constant intervention of those interested in the full exercise of rights and freedoms.

Such is the positioning of this action that it is not enough to reverse the aesthetics associated with feminist mourning. Still, the symbolic presence of the public force is necessary to establish the limits of space occupation. These types of expressions of power would evidence the multiple interests that are debated [89] over an invisible and unnoticed heritage artefact until 2 years ago, if it were not for its capacity to connect opposite ends of the city, that is, for its value of use or relationship with another asset, the Escalinata Francisco Sojos Jaramillo.

Under this consideration, what is the true social memory of the asset, and what is it that makes identity and sense of belonging possible? For the conservative segment of society, it is the celebration of the male figure of a famous politician, who gave his name to the bridge capable of resisting the traumatic flooding of the Tomebamba River in 1950, ratifying the personal mark of “Julián Matadero” [90], that ennobles the city and ratifies the progressive sense of the Castilian city. For others, it is the definition of a “movement of a new type” with imminent impact on public opinion [45] and, therefore, a new meaning and a new heritage definition capable of intensifying. Moreover, the rejection of the increase in violence, the impunity in the treatment of crimes, the normalization of this situation and the expansion of animosity of groups of men against women [45] cannot go unnoticed.

Considering that the feminist collective includes a diversity of participants, groups, organizations and individuals, the common orientation towards the bridge stands out for its significance regardless of age, race, education, or another category of population stratification or demographic characterization. Even beyond the levels of administrative regularization, formal petition [91] [2] or civic demand, the exercise of freedom of expression and respect for the rights enshrined in the Universal Declaration of Human Rights cannot be negotiated. However, it is certainly opposed to the aesthetic, symbolic, artistic and social logics of appropriating space and enhancing cultural heritage.

In this sense, and after the marked influence of patriarchal capitalism, the establishment of a structure that values the importance of the gender perspective and the public presence of women is crucial, thereby establishing solid foundations for a responsible and inclusive future for everyone, regardless of age, gender and origins [92]. While it is true that evidence shows that women and men exhibit different behaviors in public spaces, the physical structure of a city can reflect and amplify social inequalities or, on the contrary, can create more equal environments [72]. Cases such as Plaza de la República (Venezuela), Plaza de la Constitución (Mexico) and Joan Miró Park (Spain) (Table 1) confirm this not only from the rhetoric of the right to public space in the city but also from the practice of respect for fundamental guarantees such as peace and freedom. Certainly, weaknesses do not always come from legal or administrative fragility but also from the inability to implement and develop general principles in an adequate framework. In Ecuador and Latin America, in the last two decades, legislation has been passed in favor of women, thanks to the actions undertaken by national women's movements (both political and social, fundamentally) and feminists, in particular, accompanied by the response of international organizations [93].

On the other hand, concerning cultural heritage and its relation to gender equality, it is not always possible to speak of social inequalities or of any other kind, since, at least in the manifestations related to ICH, there are certain roles that are exclusive to men or women and cannot be considered discriminatory merely for this reason. However, this approach has always focused on women's participation. Still, it has not been analyzed from the perspective of discrimination or segregation that may exist in relation to the material heritage or the social use of public space in specific historical contexts. Therefore, by describing the heritage condition of the case study, concrete implications of its management and conservation can be quantified, such as limitations or possibilities for appropriation and empowerment.

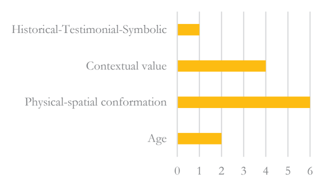
In this matter, and in official terms, the Scale of Baremo (Table 2) defines a score of 45 as a type of partial protection (Table 3). This indicates that the asset is certainly heritage because of its intrinsic characteristics and not merely due to its inclusion in a larger urban architectural complex, as it has been formally considered to date. The historical–testimonial–symbolism sub-criterion is particularly relevant, since having overcome the broad theoretical and practical debates on heritage significance, the tangible and intangible dimensions are complementary, indissoluble and of equal relevance, so that the mere physical support of what is believed to be heritage is not appropriate. This would lead to disregarding attributes and values, as well as cultural rights themselves, which are part of the so-called second-generation human rights [94], promoted to ensure that people and communities have access to culture and heritage, as well as to guarantee participation in those cultural manifestations of their choice.

In Puente Mariano Moreno, Puente de La Escalinata or Puente Vivas Nos Queremos, it is necessary to recognize the social and spatial dynamics that are part of everyday life, which promote processes of social appropriation, resignification and symbolic value [95], enjoyment of culture and its components under conditions of equality, human dignity and non-discrimination [96]. These include verifying the impact on the physical–spatial dimension of the good without compromising it (Figure 3); on the contrary, autonomy is guaranteed and relational identity is overcome.

In addition, by understanding that cultural rights have a main and undisputed addressee—the human being [94]—it is not intended that the definition of their contemporary meanings be evaluated as superfluous or frivolous due to their genesis and effervescence. On the contrary, as it is a right that attends to a need of public character [97] and evidences a progressive report of the diverse scenarios of value coming from Figure 6, it reflects a sort of socio-cultural palimpsest, which rather than generating a rupture, promotes a transition supported by the trust that, as a society, we expect to receive from the political power to eliminate any kind of arbitrariness [97] that limits it.

In this framework, and when considering the current state of the bridge and the intrinsic attributes of authenticity, integrity, uniqueness and importance derived from the historical fluctuations of the values, there is no affectation or diminution. On the contrary, according to the historical dynamics itself, it is a temporal hierarchical arrangement of priorities that reinforces its unitary character. Thus, such characteristics describe from its temporary vocation the particular meaning for the different societies for which it fulfilled a function derived from its historical, artistic, scientific or social symbolic significance [98] (Table 3). This, in turn, confirms two particulars; the first is that the physical dimension of the asset has not been affected by feminist activism or by any other social activity which has occupied the space. The second refers to the fact that heritage values cannot be understood outside the established social relations, but not all values are shared by these relations [46].

Table 3. Evaluation of Puente Mariano Moreno, Puente de La Escalinata or Puente Vivas Nos Queremos according to the Scale of Baremo. Source: [85]. Own elaboration (2022).

Baremo Scale								
Age	Grade	Score		Heritage Valuation and Degrees of Protection				Heritage value
Colonial—16th–19th century	5			No	Score	45	Degree of protection	Contains heritage value
Republican 1–19th century	4			1	46–55			
Republican 2–20th century	3	x	3	2	31–45		Partial Protection	
Republican 3–21st century	2			3	16–30			
		3		4	00–15			
Physical–spatial conformation				Assessment diagram: bar chart				
Form and design	4	x	4					
Authenticity and integrity	4	x	4					
Conservation state	4	x	4					
Use and function	5	x	5					
		17						
Contextual value								
Contribution to the shaping of the site's image	5	x	4					
Urban generators or articulators	5	x	5	Photograph of the public space valued				
Relationship with the urban-architectural environment	5	x	5					
Integration with the natural environment	4	x	4					
		18						
Historical–testimonial–symbolism								
Represents a landmark or urban landmark	4	x	4					
Related to historical events	3	x	3					
		7						

This fact is so clear that, despite the ignorance of some characteristic, attribute or value, it is possible to observe their tacit temporary existence in addition to their dynamic mutation in the future. Therefore, the participation of active subjects in the research-action process enables the generation of operational initiatives to promote the achievement of social demands [88], as well as the legitimate exercise of rights and guarantees. In this framework, the inclusion of the complex focus group refers to the following:

1. Regardless of age, gender, professional activity and place of residence (Figure 7), there is full awareness of its existence and links (positive or negative) to it. In other words, it is associated with citizens' activities, desires and imaginaries without the intermediation of physical proximity, formal education or a particular personal affinity.
2. The asset knowledge is enhanced when a potential change of meaning is thought to be opportune (91%), but it is unknown about its potential change of name (36.4%), relevance (50%) or potential impact on the conditions of the value of the asset (50%). In other words, although there is a positive trend (Figure 8), the practices, scenarios and dynamics related to cultural heritage are not universal or, failing that, are overshadowed by the political delegitimization of feminist public discourses, typical of the hegemony of temporal privilege [58].
3. The recognition of feminist social groups as actors in the public space is evident (72.7%) and could be discussed for the CHC in general (27.3%). Still, in the case of the bridge, it is overwhelming (90%) as well as the feminine presence itself (90%). This contrariety

indicates that taking into account the case of public spaces in Cuenca, the neoliberal conception mentioned by Navas and Torres [34] has resulted in their transformation into "non-places" [99], that is, spaces of transition, where urban policies have distorted the social use. This was, at least for some decades, the situation of the studied asset, which ceases to be seen as an instrument for commuting and communication to position a discourse and a forceful agenda, thereby being reconfigured as an anthropological place. In addition, to be seen as a meeting space, it remains as a catalyst for the transformation of the communal meaning of both itself and the surrounding assets. Ultimately, the positive trend (Figure 8) confirms that this is the place of local feminists.

4. The intrinsic heritage condition of the asset, regardless of specific facts or its particular value, is given by the confluence of both material and immaterial values, which are self-regulated according to transitions or time intervals [100] (Figure 6). Thus, such fluctuations reflect not only the early notion of progress but also the explosive nature of feminist activism. They have settled in the citizen's imaginary and arise from a historical process (Figure 9) in such a way that their existence and relevance for the totalitarian definition of the asset is possible and predominantly positive.

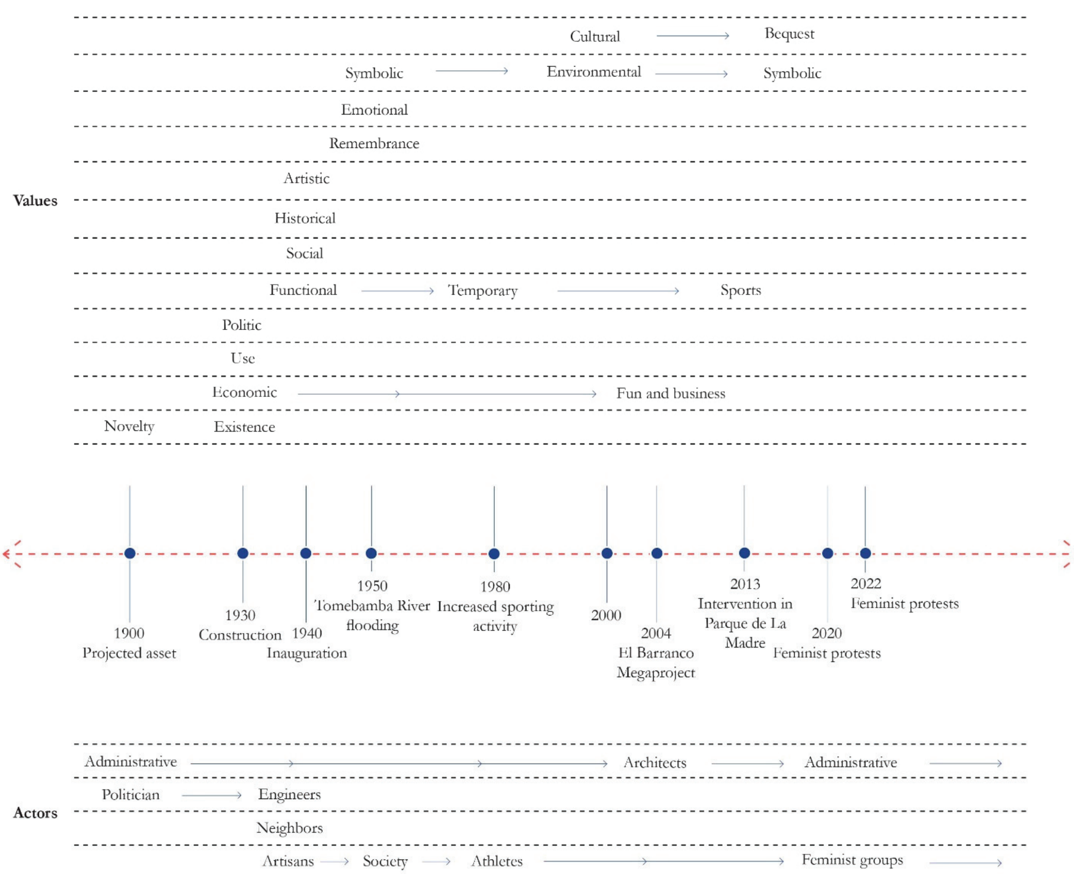


Figure 6. An overview of the evolution of heritage values in the case study. Source and elaboration: Authors (2022).

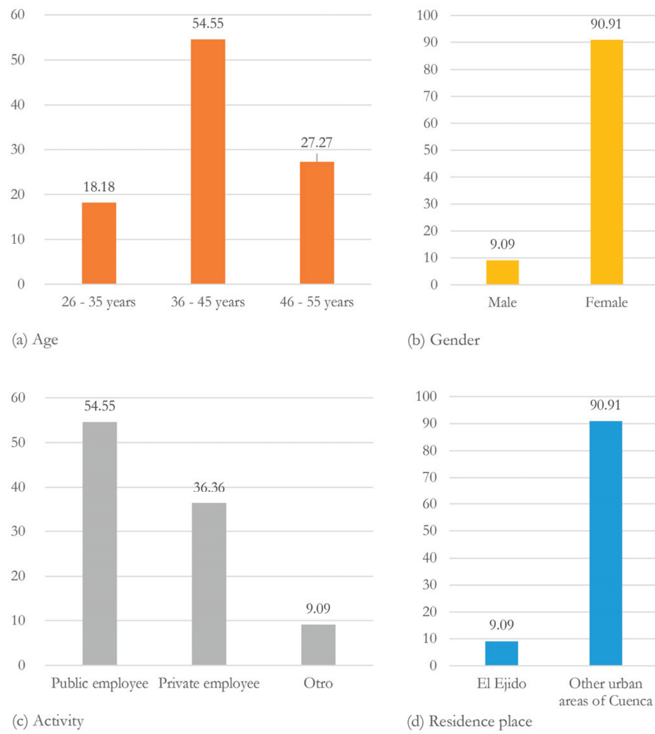


Figure 7. Demographic composition of the focus group participants. (**a**) Age of participants. (**b**) Gender with which participants identify. (**c**) Occupational activity of participant. (**d**) Place of residence of participants. Source and elaboration: Authors (2022).

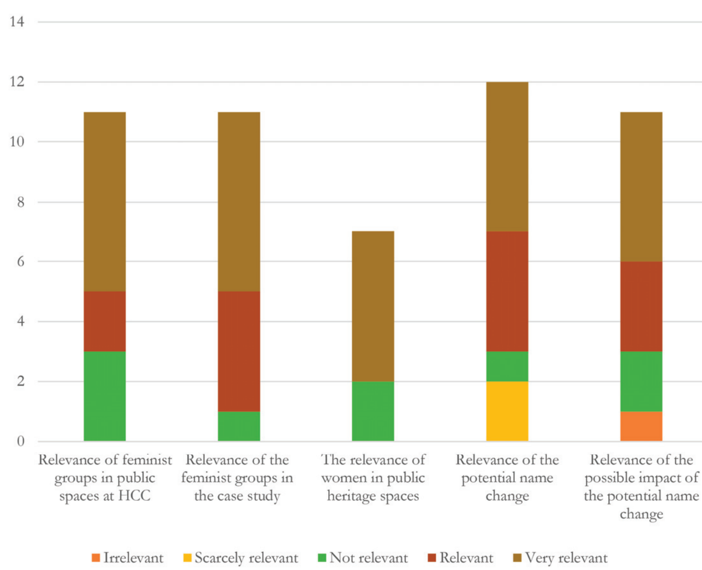


Figure 8. Global report on perception in public spaces based on the case study and feminist actors. Elaboration: Authors (2022).

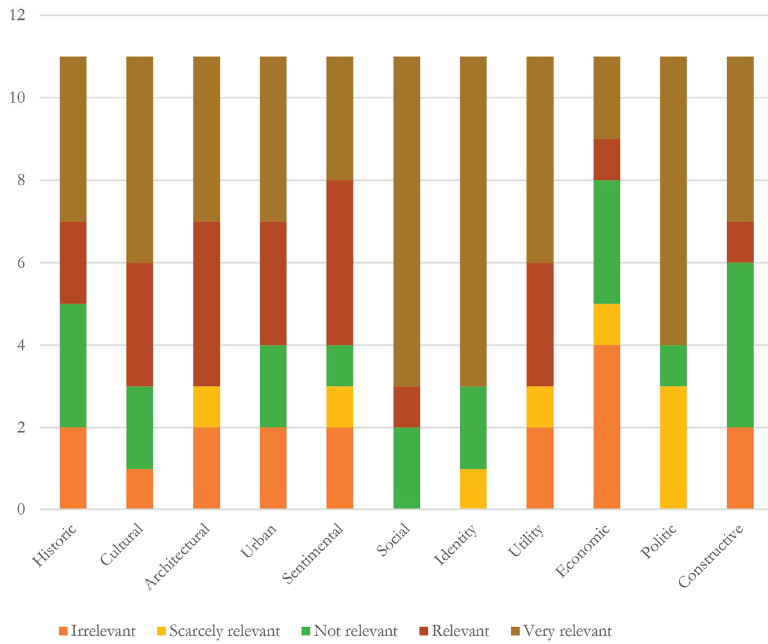


Figure 9. Global report on the case study's meanings. Source and elaboration: Authors (2022).

Additionally, what is demonstrated in terms of positive perception with signs of increase (Figures 7–9) is complemented by the recognition that the bridge as a public space is affected in its static material dimension by the feminist presence. However, this is not detrimental, as it ratifies the dynamic condition of life and its expressions and, therefore, of cultural heritage and its vocation to synthesize those expressions into recognizable values over time.

In the case of the CHC, its associated heritage areas and the case of the bridge, the heritage status is based on the recognition of unique values, but its definition is solely administrative. It lacks a participatory process such as the one exposed in this research. Without this process, it is not possible to accept with a critical and tolerant view the forms of cultural expression as articulating instruments of social coexistence [33]; therefore, its powerful visibility generates social friction; despite this, rewriting history becomes fundamental as an act of exercising rights and claiming inheritances. Considering global concern, adding a gender perspective to the new worldwide development structure has become necessary [69].

7. Conclusions

This article presents an example of a heritage asset that is currently contested. As its history has evolved, its immaterial value has continued to develop over time, acquiring values that reflect the reality of those who frequent the site. This piece's materiality and state of conservation reflect its permanence in different age groups, as well as the importance of freedom of expression to all individuals. This study illustrates the importance and influence of urban heritage by using the bridge as a medium between social reality and the population. Despite several attempts to maintain a neutral character in the material state of the bridge, the socio-spatial dynamics indicate strong empowerment that disrupts it both in the present and likely in the future. In this context, the name change proposal is ratified in the basis of its existing social value over historical, constructive or architectural values.

On the other hand, the architectural structure of Puente Mariano Moreno or Puente de La Escalinata determines the transition from one urban structure to another, from one era to another and from one society to another. It is the same with Puente Vivas Nos Queremos, although the disruptions generated are considered aggressive and informal by the most conservative segment of Cuenca. The bridge, however, integrates and is incorporated into a wide range of historical and human representations that evidence its significance both instrumentally and socially; that is to say, regardless of its name, it is a natural scenario of resignification and redefinition of its own vocation to the service of the society extended in time. Based on this, the heritage condition cannot be disputed; it is not determined by historical or current administrative constraints. The appropriation; the sense of permanence; and in a certain way, the very custody of the asset define it. In addition to the nomenclature, which serves no purpose other than to illustrate the symbolic generational association over time and consequently enhanced with the passing of time, there is no infringing action from the feminist dynamics, focusing on improving the quality of life of citizens (users and residents); promoting better urban planning strategies; and constructing public policies to encourage inclusion, respect, diversity and tolerance.

Finally, the case study has shown how the latest expressions of femicide violence in the city of Cuenca (Ecuador) have led to a renewed logic of spatial and heritage appropriation by local collectives. With this in mind, gender mainstreaming and intersectionality in contemporary society raise questions regarding current understandings, values and conservation practices. Furthermore, it promotes dialogue about women's historical role in this process and how cultural heritage assets are being redefined.

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Conflicts of Interest: The authors declare no conflict of interest.

Notes

1 In the year 2020, 4 violent femicides were registered in Azuay, which increased to 16 in the year 2021, revealing an unprecedented escalation in intimate partner and intrafamily violence.

2 The initiative was led by the organization Cabildo Mujeres of the Cuenca canton. It was considered through regular proceedings before the Commission for Historical and Heritage Areas of the Autonomous Decentralized Municipal Government of Cuenca in ordinary session No. 33 of 2020. The petition included the execution of various artistic expressions [92], which were approved [47], unlike the name change.

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Strategies for Sustainable Urban Renewal: Community-Scale GIS-Based Analysis for Densification Decision Making

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Abstract: China is gradually shifting towards more sustainable urban development, and the local governments are increasingly promoting social and environmentally sustainable spatial planning practices. This article debates the potential contradiction between the goal of a constantly growing urban population and the limits to the consumption of land planned by this new direction of urban development. The analysis focuses on the wealthy city of Suzhou in the Yangtse River Delta region and explores the opportunities for densification of the residential areas as a possible solution for this contradiction, as already tested by some Chinese cases for land use efficiency. The research applies GIS-based spatial analysis and identifies some of the sites that can be efficiently redeveloped in the resettlement communities for their low floor area ratio (FAR) and obsolescent conditions, which do not correspond to the increasingly middle-class status of the residents in the urban region. The article investigates the different options of a densification strategy in the frame of the policies of urban renewal promoted in China in recent years for improving the quality of the built environment.

Keywords: sustainable urban renewal; densification strategies; resettlement communities; GIS-based analysis; decision making

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1. Background

1.1. The New Urbanization "Beyond Mere Growth" in China

Since 2014, the Chinese central government has promoted new-type urbanization in the *National New-type Urbanization Plan (2014–2020)* [1–3]. The direction of the plan "beyond mere growth" supports green and low-carbon development and requires avoiding urban sprawl, low efficiency in land use, the proliferation of useless urban districts, and waste of urban space in over-dimensioned infrastructures [4,5]. Consistent with the goals of new-type urbanization, the national guidelines on urban planning released in 2016 prohibit expanding cities beyond what their natural resources can support, enforcing urban growth boundaries [6]. In other words, to be sustainable urban development should not expand beyond a planned threshold, as also required by the environmental protection laws issued since 2015. This limit to expansion is also known as the "red line of China's cultivated land", and was first drafted by the National Land Planning Outline issued by the Ministry of Land and Natural Resources in 2009, which also specifies that the impermeabilization of the ground should be diminished [7].

These policies for preserving agricultural land are combined with the regulations for controlling land supply and the real estate market. Since 2003, the central government established year-by-year construction land development quotas for every local government according to the assessment of the local demand–supply situation [8–10].

Together with the sustainability goals, the increase in the urbanization rate is a key national priority in China. It has been one of the most significant drivers of economic, political, and social progress since the reform was promoted at the end of the 1970s [11–14]. So far, urban population growth has followed economic growth because economic development and city growth are strongly related to Chinese policies. The massive urbanization process has transformed millions of farmers into city dwellers, attracting an essential workforce into the expanding city [15,16].

These recent policies promoted by the Chinese government—on one side the goal of a growing economy and on the other side the limits to urbanization to protect fertile land and natural environments—can produce a contradiction and urban concentration: probable newcomers in growing cities and industrial districts versus a not expanding city.

1.2. The Solution of High Density for Growing Cities and Sustainability

Multiple actions should be considered for promoting urban sustainability, such as limits to new urbanizations and conservation of agricultural land, investments in public transportation [17], limits to car-oriented projects [18], reduction in energy consumption and greenhouse gases emission in all sectors of production, water management [19], and improving water, soil, and air quality [20]. Of the multiple elements that impact the sustainability of urban development, this paper focuses on the quantitative parameter of population density on urbanized land, more specifically on the opportunity to increase the dwelling units in existing residential neighborhoods. The research presented in this paper applies urban-scale GIS analysis to make some hypotheses on densification at the community scale.

Density is neither a good nor a bad indicator: too much can result in overcrowding and eventual urban decay; too little can deprive the dwelling environment of the chance of social interaction and public transport efficiency [21]. The definition of density is, nevertheless, closely connected to sustainability because land is a limited resource; urbanization is "sustainable" when valuable agricultural land is saved, and the ecosystem is not jeopardized.

High density has both positive and negative effects. Many scholars have presented evidence that higher density in urban areas is associated with a variety of desirable outcomes, including increased use of public transportation, improved financial stability for local governments, walkable and healthy living environments, housing diversity and affordability, enhanced community character, and cultural vitality [9–13,22–28]. Other scholars, on the contrary, have noted how some high-density neighborhoods produce excessive concentration and congestion, difficult management, and inefficient facilities. The issue cannot be assessed in general terms because the output of high-density conditions depends on several context-related factors, such as urban planning strategies, technical capacity, building regulations, infrastructure, public utilities, regional services, and the economic conditions of the residents [29]. For example, the interplay between density and building types must be considered because the same FAR realized by different architectural forms and open spaces produces different urban environments. In China, the different ranges of FAR—usually classified as low, medium, and high in building regulations and master plans—often correspond to specific building types; for example, medium density is realized with multilayer condos [30–33].

Over the last two decades, the idea of urban densification has been explored worldwide in several large cities and also in medium or high-density cases [34–38]. These densification projects are promoted mainly for the following reasons:

1. The high value of the land combined with the increased demand for housing is a potential profit for the developer if what exists is demolished and rebuilt at a higher density.
2. The available buildable land is either scarce due to geographical conditions or limited by the local regulations for protecting agricultural land.

Both reasons justify the actions of densification promoted in dense cities, such as Paris [39,40], Seoul [41–43], Rotterdam [44–46], or London [47–49]; policies and projects differ among cities because they adapt to local conditions, including the socio-cultural approach to dwelling.

Regarding China's concerns, often urban land expands faster than population growth. In recent years, this trend has impacted several Chinese cities, which have experienced declining densities, very likely due to the rising average income leading to the demand for more residential space per capita, and for the restrictions due to the hukou system (a household registration which prevents the change of residence in order to limit the number of permanent residents in cities) [50,51]. According to the World Bank, even though China underwent massive urban population growth, its urban population density in 2010 was lower than the average of the rest of the East Asia region [52].

1.3. The Case Study: Suzhou's Shift in City Planning and Manufacturing

Suzhou is a prefecture-level city in the Yangtze River Delta region and has greatly developed since the reform and the establishment of the Suzhou Wuzhong Economic Development Zone in 1993 [53]. In fact, in 1990, its gross domestic product (GDP) was RMB 20.214 billion (USD 4.23 billion), and in 2019 it skyrocketed to RMB 1.92 trillion (USD 290 billion) with a registered foreign capital of RMB 646 billion (USD 99.9 billion) and per capita GDP of USD 25,900, ranking third in China. In 1990, the population of permanent residents in the metro area was 1,067,000; in 2019, it was 7,070,000 [54].

Suzhou is a production hub in the Yangtze River Delta area and China's third-largest manufacturing city [53]. In the future, it will keep attracting new inhabitants if it remains competitive. With this goal, the local government is promoting the re-branding of its manufacturing, a shift to creative and innovative productions according to the policy of the central government [8]. To realize this shift, Suzhou needs to attract the ones who can support this digital empowerment: talents and high-level professionals with their families [55]. In fact, according to the report *Chinese Cities of Opportunity 2021*, by the China Development Research Foundation, Suzhou is in a good position for technical maturity but not for intellectual capital and innovation. The city established some policies to attract talent and train graduates in 2020 [56]. Together with these high-skill jobs, the city will attract lower-income workers such as babysitters, cooks, cleaners, carpenters, and health and well-being workers: every high-skill job produces at least five jobs in other sectors [57,58]. These newcomers must find a long-term accommodation that fits their expectations in the city.

In compliance with the national guidelines for supporting sustainability, the recent Master Plan for Suzhou 2020–2035 promotes the preservation of natural resources and stops massive urbanization. This master plan does not establish the future threshold of population growth; this is because in the past development proved that each planned threshold of the total number of inhabitants was underestimated [59].

1.4. Sustainability Versus Growth: A Potential Contradiction in the Development Goals

In a city becoming wealthier such as Suzhou, if the limits to new urbanization are implemented, a problem in quantities of the housing stock can be foreseen, as well as in the quality of the built environment. Very probably, the middle class in Suzhou will keep increasing in number and spending capacity, and very likely, the low-income people will increase their income and their requirements in choosing the family house [60–62].

Suzhou has a significant housing vacancy rate; the data are unavailable, but likely it is around 20%, as in similar cities in China [63,64]. This could be considered for future demand, but in general, the empty stock cannot be considered for renting, mainly because the real estate investment target is quick and consistent value increase, not rental returns, which decreased to less than 3% in 2018 [65,66].

Given these premises, the implication of the policies is that a larger population must occupy a limited urban land, but at the same time, a wealthier society requires higher living standards. Starting from the hypothesis that in Suzhou land must be used efficiently and that housing quality should improve, this research discusses the issue of density. If the GDP per capita of Suzhou and its population keep growing while the city wants to avoid sprawl, Suzhou could consider renewing some already developed areas, increasing density, housing offers, and overall livability.

1.5. The Structure of the Paper

This research explores the possibilities of densification in Suzhou to accommodate a larger quantity of population of different incomes and consume less agricultural land for urbanization. This paper discusses a strategy for sustainable urban renewal with densification; the strategy defines three options of intervention, which answer the main research question: where, how, and why requalification with densification can be applied.

This paper has the following structure. The first part presents the background of the research: the new-type urbanization policy in China, the idea of high density as a solution for sustainability, the growing population in Suzhou and its increasingly middle-class status, and the possible contradiction caused by the limits of land consumption in the Chinese context. The second part of the paper explains the reasons for urban densification in high-density urban areas and introduces some examples. The third part presents the resettlement communities in Suzhou as a relevant case for the densification strategy. The fourth and fifth parts investigate the case study with GIS-based analysis and propose some options for densification, combined with improving the built environment's quality. The last part proposes some conclusions about the potentialities of densification in a specific context, and the research limits.

2. Growing Population, Land Consumption, and Densification

2.1. Density Parameter

As introduced in paragraph 1.2, the parameter of density is a quantity and results from the combination of housing types and compactness. Usually, the quantities of population density and floor area ratio (FAR) are used to indicate density level. FAR is the parameter adopted in the regulatory plans in China to calculate built-up area density: it expresses the ratio between the total built surface and the dimension of the site where the buildings are [67]. FAR varies among the various urban areas in Suzhou, and the city as a whole cannot be classified as a high-density city if the rankings of some authoritative institutions are considered such as the World Atlas [68], UN-Habitat, Demographia World Urban Areas, the Atlas of Urban Expansion, and the Global City Power Index [29].

Population density expresses the ratio between the quantity of the population and the location [69–71]. The population density in the central district of Suzhou and the five adjacent districts (Gusu, Xiangcheng, Suzhou Industrial Park, Wuzhong, Suzhou New District, and Wujiang) was 2315 people/sq km according to the local government in 2021. The ratio between urban population/urban area in the metropolitan area is roughly less than 1/3 of the ratio in Singapore (generally ranked around 10,000 people/sq km), half the density of Shanghai, which is not ranked as one of the densest in the world (Table 1). These quantities allow us to claim that Suzhou is not a high-density city and to call the recent expansions of Suzhou "high-density sprawl" [30–33].

Table 1. Area and population indicators of each district in Suzhou.

District	2021 (Million)	Area (km^2)	Pop Density
Metropolitan Area	12.748	8657.32	1472.5
Suzhou City	6.7148	2899.38	2315.9
Gusu	0.924	83.42	11,076.5
Wuzhong	1.3889	745	1864.3
Xiangcheng	0.891	489.96	1818.5
Suzhou New District	0.832	332.37	2503.2
Suzhou Industrial Park	1.1339	278.19	4076.0
Wujiang	1.545	970.44	1592.1

2.2. Densification in High-Density Cities in China: The Direction already Taken

Actions for densification have already been taken in China: in 2003, the "prohibition of land supply for villas" was issued to stop low-dense developments by the Ministry of Land and Natural Resources. The rule had to be repeated five times because it was not fully implemented. In 2019, the Ministry of Housing and Construction issued an urgent notice requesting the suspension of the approval of projects proposing villas. Subsequently, the limit to the minimum FAR was extended to all low-density typologies such as villas, double-family row houses less than four stories, and townhouses.

The "prohibition of villas" is justified by China's arable land sharply decreasing [72]. The National Land Planning Outline required in 2006 that by 2020 the amount of cultivated land would be maintained at 1.865 billion mu, a goal implemented by the "red line of cultivated land" and the construction land quotas mentioned in paragraph 1.2. The goal was achieved, and the same amount of 1.8 billion mu is set for the future [73].

Beyond the prohibition of low-density developments and the red line, densification processes are happening: two very relevant cases are Shenzhen and Shanghai.

Shenzhen is running out of land supply for development: only 2.23% of the 195,284 hectares of the city is still available for growth, and real estate prices have sky-rocketed. Therefore, Shenzhen is demolishing and densifying some already high-density residential areas. This phenomenon interests mostly the "villages in the city", where in the 1980s, after opening up, the original 1-story buildings were extruded to several stories and almost to the whole lot, forming in several stages a hyper-compact urban fabric [74,75]. An example of this process is Dachong village (Table 2). The area used to house 931 families in 1400 buildings on 69 ha (13.5 families per ha), but in 2011 the whole village was demolished, the building type changed, and the density increased from 1.1 million sqm to 2.8 million sqm and 7382 residential units (107 units per ha). The transformation also increased the land uses, shifting from residential to mixed-use conditions. These actions of densification can be controversial because they often start gentrification [76,77].

Table 2. Comparison of Three Typical Update Project Indicators.

Village Name	Site Area	Total Building Area (Before)	Total Building Area (After)	FAR (Before)	FAR (After)
Dachong village	36.40 ha	160.52 ha	280.00 ha	4.41	7.70
Jianyeli Shikumen	1.79 ha	2.33 ha	4.77 ha	1.30	2.51
Tuanjie Village	2.80 ha	4.43 ha	14.11 ha	1.58	5.04

In Shanghai, the FAR of low-rise and high-density houses has generally increased. In recent years densification has happened mostly along the metro lines and central streets, for example, in Hengshan Street, where towers have substituted the original low-rise urban tissue [78].

Moreover, resettlement communities are impacted by densification. High rises fill empty lots, such as the "Vertical courtyards apartments" in Hangzhou by Wang Shu [79] and "The third space" in Tangshan by Li Xing Gang or entire parts are demolished and rebuilt, such as the Tuanjie Village in Kunshan, Jiangsu province. A trend of increasing the FAR of the resettlement communities can also be noted in Suzhou over the years after 1999: the new communities are designed to be slightly denser than the previous ones.

3. Data Acquisition and Research Method

The research focused on the resettlement communities in Suzhou for several qualitative and quantitative reasons:

- They are spread all over the municipality and occupy already urbanized land;
- They house a large population, but some of them are low density;
- They offer different conditions in relation to accessibility;
- They are becoming obsolete in absolute terms and in relation to the growing income of households.

3.1. GIS Spatial Analysis: Location, FAR, Accessibility, and Housing Conditions

Resettlement communities are where the government relocated the farmers who lived in the demolished villages. Suzhou's urbanization process demolished many rural villages, and the inhabitants resettled in urban communities built cheaply and quickly for this purpose [80–84].

The research has identified 176 resettlement communities in a 50 km diameter area centered in Suzhou old town and involving the central 6 districts of Suzhou (Gusu, Xiangcheng, Suzhou Industrial Park, Wuzhong, Wujiang, and Suzhou New District) (Figure 1). They were built in the late 1980s, occupy more than 2200 ha, and consist of almost 360,000 residential units with approximately 1 million people. Still, their population is floating as these communities include a large percentage of immigrants. The average number of units is around 2000; the largest community has 14,000 units, and the smallest has 112 units.

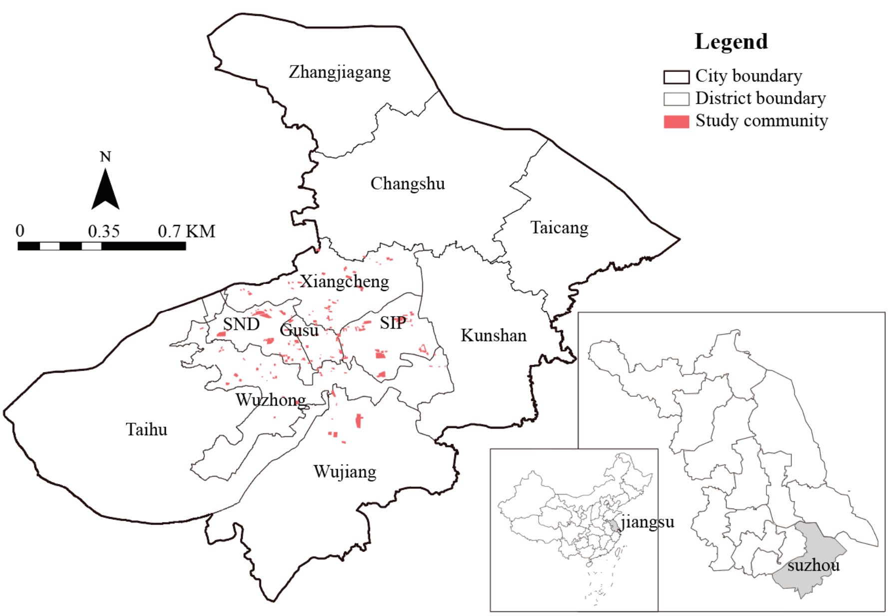

Figure 1. Resettlement communities' location in Suzhou.

Official data about the resettlement communities are not available. A general survey of the resettlement communities was conducted with site visits and GIS analysis of the built stock, the green spaces, and the mobility system using satellite images from 3 platforms [85,86]: Google Earth, Baidu maps, and Suzhou map 512, which is the official website of the Suzhou Natural Resources and Planning Bureau. This analysis defined the essential land-use parameters of every community: the area of the occupied land, the building coverage, the green coverage, and the gross floor area (GFA).

The data available online on the webpages of the real estate agencies managing the communities stock allowed us to identify the construction year, the total number of residential units, the minimum and the maximum units' dimensions, the GFA, and the number of floors of the different buildings (Tables 3 and 4). According to these data, the FAR was calculated in every community.

Table 3. A detailed description of the data source used in the research.

Item	Source	Time
Basic information	Data acquisition source is Gaode, Suzhou Map, Accessed from: https://1bs.amap.com/ (accessed on 1 September 2020).	2020
POI, AOI data	Suzhou Anjuke Second-hand Housing Trading Website. Accessed from: https://su.fang.anjuke.com/ (accessed on 1 September 2020).	2020

Table 4. Measurement method and analysis equation.

Measurement Item	Equation	Meaning
FAR	$F_x = F \times L$ $FAR = \frac{F_x}{A_x}$	F is the single-story building area, L is the number of floors of the building F_x is the total building area, A_x is the plot area
Community accessibility	CA = NQPDAn in sDNA + N_{C1}	NQPDAn is an indicator in sDNA that calculates global accessibility, reflecting the accessibility level of roads based on its numerical value. N_{C1}, Number of transportation stations within 300 m around the community. CA means community accessibility.
Housing conditions	$\mathrm{HC} = T_{H1} + N_{H2} + \frac{S_g}{S}$	T_{H1}, the community house price; N_{H2}, the number of households in the community; S_g, greening area of the community; S, area of the community; and HC means housing conditions.

The basic spatial data were analyzed with the POI (point of interest) and AOI (area of interest) data. Community basic data refer to the list of resettlement communities, community construction years, average housing prices, number of building floors, and real-life photos obtained from the Anjuke lnc. (a second-hand housing trading website) and the Renting website. POI and AOI data were sourced from the open platform of Goddard, and the POI points in the Suzhou area were crawled from the API interface. There are 20 categories of POI on the map of Goddard, such as catering, shopping, life, sports, leisure, medical care, accommodation, public facilities, etc. Each significant category also has secondary and tertiary subdivisions. AOI refers to POIs with planar and regional characteristics, including but not limited to industrial parks, school campuses, commercial districts, residential communities, scenic spots, train stations, airports, and other types of POIs.

The calculation formula (Table 4) mainly includes three aspects: FAR, community accessibility and housing conditions. The calculation formula for FAR is based on the number of layers and AOI calculations verified by satellite images. Community accessibility is, on the one hand, the road reachability calculated by spatial design network analysis (sDNA), and on the other hand, the calculated public transport allocation level around the community. Road accessibility and public transport were added at the data level, and the final results were presented in five categories using the natural discontinuity method throughout the entire research scope. The housing conditions evaluation includes metrics such as housing price, number of households, and greening rate. The housing price, number of houses, and green rate were added at the data level, and the final results were presented in five categories using the natural discontinuity method throughout the entire research scope. In addition, we also calculated the combination of three indicators: FAR, housing price, and accessibility, and the results were visually overlaid by three indicators, presenting different results based on different colors.

3.2. Empirical Observation and Field Study: The Obsolescence of the Existing Resettlement Communities

A detailed analysis of the spatial features of six communities was carried out, which represents well the characteristic conditions of this kind of settlement in Suzhou (Figure 2). The communities are:

- Li He Village, started in 1994 in Gusu District;
- Nanhuan Community, started in 1996 in Gusu District;
- Dengyun Community, started in 2000 in Xiangcheng District;
- Lotus Village, started in 2002 in Suzhou Industrial Park;
- Bibo Community, started in 2001 in Wuzhong District;
- Mabang Community, started in 2002 in Suzhou New District.

Figure 2. The typical inner courtyards of the resettlement communities.

The direct observation of the resettlement communities highlights how some elements and standards are constantly repeated:

- Standards in building characteristics: housing type (multi-story with central staircase and 2 apartments on every floor), number of floors (4–6), depth of buildings (8–12 m with verandas);
- Standards in the spatial layout: orientation and alignment (east–west), distances between buildings (the minimum provision is that the sunshine must enter the ground floor for at least 2 h every day according to the regulation), functions (mono-functional: residential with some public facilities for gathering), and dimensions and features of the common open space;
- Standards in construction quality in compliance with local regulations [87].

The direct observation of the spatial characteristics of the case study was combined with some data on urbanization in Suzhou, such as the rapid growth of the wealthy middle-class population, the rapid adjustment of the economic structure, and the constant attraction of new residents over the years. This allows concluding that resettlement communities can be considered a potentially transformable part of a city for four reasons:

1. Buildings often have problems with poor construction quality and outdated equipment and appliances. When the building is more than 15 years old, which is often the case in Suzhou resettlement communities, sewage, pipelines, heating and cooling systems, waste management, water and electricity, and waterproof and acoustic equipment should be updated. Regarding the quality of building structures, the Unified Standard for Reliability Design of Building Structures (GB50068-2001) in 2001 first proposed the concept of design service life: it defined the design service life of building structures and structural components as 30 years; in recent years, this service life has increased to 50–70 years [88].
2. Residential units and public spaces have problems connected to the low standards of their construction period. This includes a lack of elevators, insufficient parking spaces, units often too small to accommodate a comfortable kitchen with a dishwasher and two bathrooms with washing machines [89]. Therefore, the local government is taking measures to address these issues. For example, in October 2018, the local government launched the "Suggestions on Installing Elevators in Existing Multi-story Residential Buildings in Suzhou" to adapt to economic and social development, improve the functionality of existing housing, and improve living standards [90].
3. The value range of FAR is relatively low, indicating that these communities have a small population density and belong to low-density communities. This situation is not due to the age of construction, but rather to the project conditions and the number of people that need to be accommodated [91].
4. The construction method usually adopted a "copy-paste" method to provide similar living conditions while reducing costs and accelerating speed. However, in the future, with the development of China's economy and the improvement of people's living standards, these demolished and rebuilt communities may be considered low-level housing environments. Therefore, there is a need to reassess these communities and explore their sustainable development potential, including investigating possible personalized schemes to provide housing for more and different types of residents and promote community diversity and sustainable development.

One element to take into consideration for the definition of the densification level is the existing regulation. At the national level, when the resettlements started to be designed in large quantities in the special economic zones, the Code of Urban Residential Areas Planning & Design GB50180-93 (updated in 2002, issued by the Ministry of Housing and Urban-Rural Development), article 5.0.6.2 [92], decided that the communities designed as the resettlement communities—the multilayer housing—must not have a FAR higher than 1.8. The most updated version of this code for the same kind of communities issued in 2018 defines a range of 1.6–1.8, but these national limits can be exceeded and should be reassessed at the municipal government level to become context driven.

4. Research Results: The Resettlement Communities as an Opportunity for Renewal

In a fast-changing China, where the middle class is rapidly increasing and consumption is encouraged, and especially in Suzhou, a city that wants to shift to creative and innovative productions and attract talents, the existing obsolescent resettlement communities—initially built for farmers and families with a low income—are not considered housing environments able to provide an up-to-date standard of living in the near future. Considering the obsolescence on one side and the improvement of economic conditions on the other side, the resettlement communities can be considered a part of the city to renew.

This idea of renewal is coherent with the guidelines of the national government established in *the 14th Five-Year Plan 2021–2025* for the national economic and social development of the People's Republic of China. In the *Outline of Long-term Goals for 2035*, for the first time, China has officially promoted an urban renewal approach to improve the existing built environment next to the usual large-scale incremental development. The plan supports the renewal of the communities built before 2000 and the policy of regeneration that targets the "three-old"—that is, the old village, the old town, the old factory—by "encouraging intensive land use" that started in Guangdong province in 2008 and spread to the whole country [93,94]. Suzhou is included in the demonstration sites for old town renewal.

4.1. GIS Spatial Analysis Results

In this transformation, densification can be considered to increase land-use efficiency, renew the obsolescent stock, and provide housing to more diversified inhabitants. The analysis of the parameter of the density of the 176 resettlement communities in Suzhou already shows a small trend of densification over 30 years. In the early years of urbanization, the units were smaller, and the FAR was lower, less than 1.3; the cases with a FAR higher than 1.5 were realized after 1999, but in the 2000s, FARs higher than 2 and lower than 1.5 coexisted. After 2008, almost no communities had a FAR lower than 1.5. Since 2016, nearly all cases have had a FAR higher than 2, with some also reaching more than 3, and units becoming larger (Figure 3).

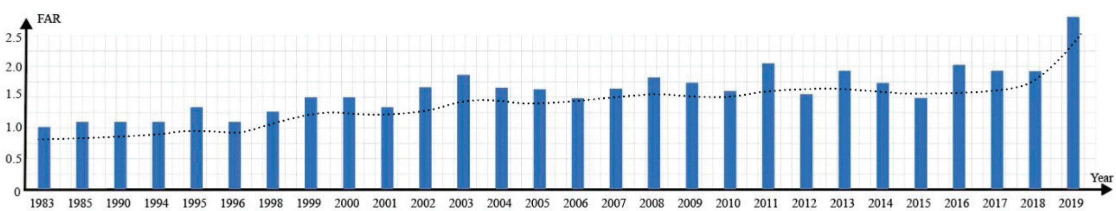

Figure 3. Average resettlement communities' FAR change from 1983–2019 in Suzhou city. (The dashed line is the trend of the column chart).

According to the FAR calculation via GIS (Figure 4a), 42% of the resettlement communities have a FAR between 1.0 and 1.5; a total of 35% have a FAR between 1.6 and 2; a total of 19% have a FAR higher than 2; and 4% have a FAR lower than 1. The analysis does not show a general rule in the distribution of the resettlement communities in the city, and neither can reasons be found for the different FARs of the cases, if not a higher FAR in proximity to the edges of Gusu, the oldest district of Suzhou, and a lower FAR in the most distant ones from Gusu.

For the house conditions calculation (Figure 4b), the areas with the highest housing conditions are located around Jinji Lake and Dushu Lake in the industrial park, at the junction of Gusu District and the industrial park, near Xinqu Road, and exhibit a typical centrality, with lower housing conditions occurring further to the periphery. Compared with areas with high housing prices, areas with lower housing conditions have wider coverage and cover the complete urban development boundaries. Low-density resettlement communities tend to concentrate in areas with slightly higher urban housing conditions.

For community accessibility analysis (Figure 4c), the highest area is located in the area west of Jinji Lake in the industrial park and at the junction of the ancient city, as well as the area around Dushu Lake. Similar to housing prices, it shows a clear centrality. However, compared with housing prices, its coverage area is relatively small, located in the city's core area. In addition, there is no obvious consistency with reachability for low-density and high-density resettlement communities.

According to the integration analysis of accessibility and house conditions superposition (Figure 4d), the area with high house conditions and accessibility is the area where the industrial park is close to Gusu District, which has a strong centrality in the overall distribution. However, because the two are not completely superimposed in space, the core area radiates from the industrial park to the new area, forming a larger radiation area.

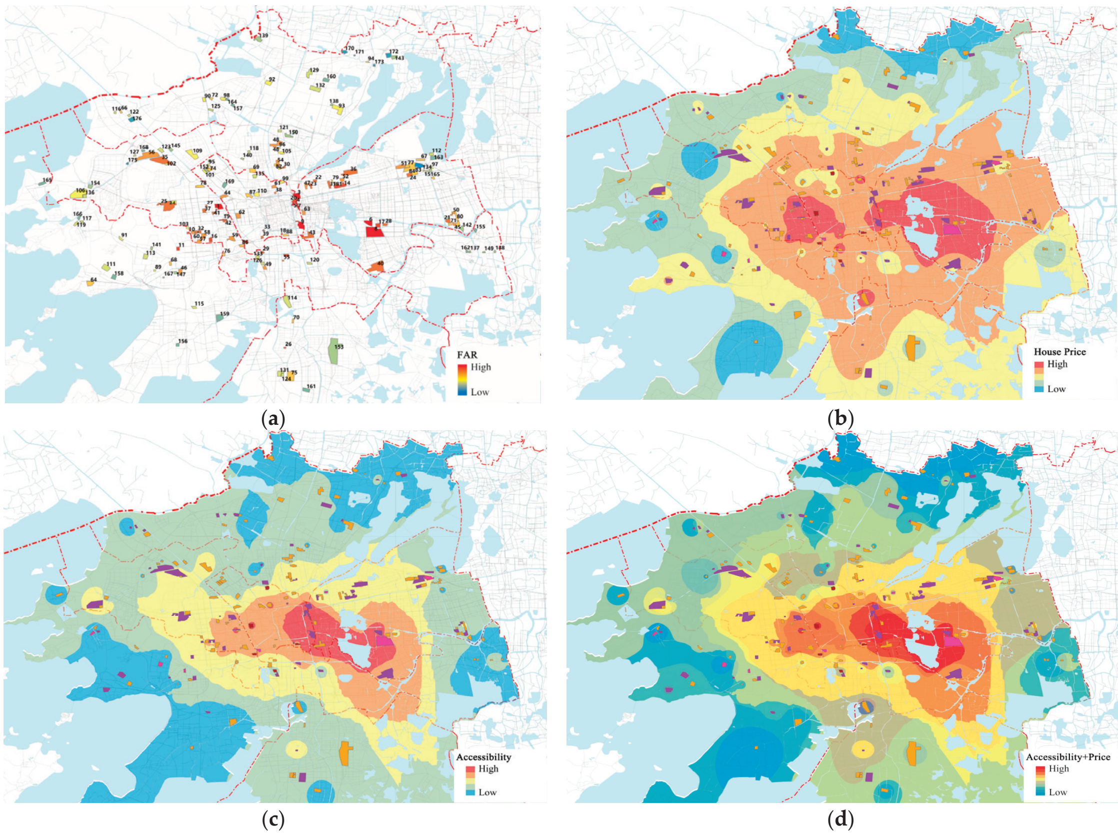

Figure 4. The GIS analysis. (**a**) The location and the FAR of the 176 resettlement communities identified in Suzhou. (**b**) The resettlement communities and the areas with different housing conditions. (**c**) The resettlement communities and the areas with different accessibility (bus stops and subway stations): the red areas represent the best accessibility in Suzhou. Note: accessibility is calculated using sDNA from the urban road axis model. (**d**) The combination of three indicators: FAR, housing conditions, and accessibility.

4.2. Statistical Analysis of Six Communities and Nanhuan Community

The 6 communities analyzed in detail have a floor area ratio that ranges from 0.95 to 1.75, on average 1.27, while the average FAR of all 176 cases is 1.73, the minimum is 0.7, and the maximum is 3.87 (Table 5).

For example, the Nanhuan New Village in Suzhou is a noteworthy case of densification. It is a demolition and reconstruction project in Suzhou, which was completed in 2013. Unlike the original community, the new community uses high-rise building types and different green space layouts, increasing the FAR value from 1.1 to 3.87 and tripling the total number of units. This attempt has shown that renewal is also a viable option when reassessing and transforming demolished and rebuilt communities, which can promote sustainable urban development while providing more housing.

The highest FAR is in Nanhuan New Village, Gusu District, which is the only case in Suzhou of the renewal with densification of a resettlement community, Nanhuan Community, initially built in 1996 on agricultural land. In 2013, the former community was partially demolished and rebuilt with a different housing type, high-rise buildings, a different layout of open space and green areas, and a FAR more than 3 times the former one, which was 1.1.

Table 5. Comparison of the main characteristics of the traditional resettlement village in Suzhou with Nanhuan New Village.

	Average of 6 Case Studies	Nanhuan New Village
FAR	1.27	3.87
Housing type	Multi-story	High rise
Number of floors	4–6	28–32
Green coverage	0.35	0.25
Construction cost	1200 RMB/sqm	2500 RMB/sqm
Car Parking	No structures nor areas for parking in the original master plan; parking was obtained in recent years in the green spaces.	Underground parking, 0.8 car parking for every unit
Comfort	No elevator	Elevator
	No heating or air conditioning	Heating or air Conditioning
	No soundproof walls	Soundproof elements
	No thermal insulation	Thermal insulation
	Fragmented open space	Continuous open space

5. Discussion: A Strategy for Renewal and Densification

If the resettlement villages are chosen as targets for renewal and densification because of their architectural and urban characteristics, which ones should be selected and why? This paper proposes three options and evaluates their possible significance.

Based on the GIS analysis, some rationalities for selecting which communities to densify can be proposed, together with a process of gradual transformation in the medium term according to the existing policies. The project of densification should be site-specific and take into account multiple factors; that is to say, each specific renewal can define how to optimize the FAR in the re-design of the site, but some general conditions where densification should happen can be identified.

The paper considers the residential neighbourhood's main quantitative factors—number of units and residents, dimensions of the area, public transportation, and period of realization—for a quantitative investigation of the possibilities of transformation with densification with the goal of using more intensively the land already urbanized. Before real actions are promoted, every proposal of densification will assess if the land is suitable for densification due to soil and seismic conditions, the land carrying capacity, and the land subsidence risks. The potential impact of natural disaster on the increased concentration of residents will also be explored to assess the possibility of safety in an emergency. During the decision-making phase, feasible mitigation and compensation measures will be studied to balance the impact on the environment of the demolition and building activities [4,5,7,17,19,20,69–72].

5.1. Densification according to FAR and Accessibility

The first option is the selection of cases to renew according to the intensity of land use expressed as FAR. Renewal and densification should be proposed in the resettlement communities which:

- Do not efficiently use the land they occupy because the FAR is much lower than the average of the communities: the ones where FAR is lower or equal to 1 (8 cases) should be the first to be renewed; the ones with FAR lower or equal to 1.2 (18 cases) should be considered as the second group. In total, the communities with FAR lower or equal to 1.2 now accommodate almost 128,000 people in 40,423 units;
- Were built before 2000 (12 cases), as proposed by the national guidelines, which today in the cases in Suzhou accommodate almost 78,000 people in 25,956 units;

- Next to metro stations or transport interchanges (within 400 m from one of the community gates) and have a FAR lower or equal to 2 to fully exploit the transport capacity and accessibility of the site. Specific projects should define the most proper threshold of FAR according to the local conditions and the transport capacity.

The analysis of the available GIS data of the built fabric and the public transit infrastructures allows us to determine which resettlement communities are both low-density and within a radius of 400 m from a subway gate or a bus interchange, or a terminal (Figure 4c).

These first groups of communities can be pilot projects to test potentialities and obstacles to realize the optimum potential of sites. To what extent the FAR can be increased must be assessed in the local context, and multiple factors must be considered, including social infrastructures.

Other indicators can be considered to propose a community renewal, such as the quantity and quality of the open and recreational space. The communities with a building coverage higher than 25% and a green coverage of less than 30%, which means the open area of the community is mostly for mobility, should be investigated to assess the quality of the open space they offer combined with the FAR.

If this renewal happens, the value of the redeveloped estate will exceed the original value of the estate plus the cost of change, which is the expense, the temporary problems for the inhabitants, and the impact on the environment for the demolition and rebuilding. The upheaval of people's lives and improvement of living conditions should be included in the viability assessments, and some form of subsidy should be provided. These concerns are partially reflected in China's national compensation policy, which considers the residents' needs while dislocated; its main elements are:

1. It grants financing for rental payments depending on the number of family members;
2. It compensates N times ($n > 1.2$) the value of the former residential area;
3. The resettlement solution is either in the same place as the original community or not far from it;
4. The indoor decoration of what is lost is compensated in cash [95].

In general, the evaluation of increased density should be in relation to the perception of the urban environment from the inhabitants, and high density must avoid extreme living conditions [24] (Figure 4b). Local public participation processes should be organized to involve the inhabitants in the decision making processes, but this is still rather rare in China.

5.2. Densification according to Housing Conditions

Considering the relevant investment needed, the social trade off, and the fact that new constructions are resource intensive and have high environmental impacts, the second option evaluates a non-destructive solution and the upgrading and retrofitting of the existing structures [96]: actions of densification that maintain the existing structures can be designed. The examples of Seoul and Rotterdam show it is possible to infill, build over, and build in-between existing buildings, even though these actions usually cannot substantially increase the number of people in the communities. They invest a few resources, do not demolish the houses of those who have already experienced one resettlement, and reduce the impact of reconstruction on the environment [97].

Specific projects must define these punctual actions of densification and their contribution to the whole city housing offer cannot be esteemed without a general plan that sets goals and targets. These kinds of actions indicate that to grow denser might be to build a compact city, not a super-density city [98,99], and might be to realize different housing types than the ones usually built in Suzhou, such as the compact superblock. A research-by-design or a design competition for new housing types in Suzhou should be promoted (Figure 4c).

5.3. A Radical Scenario of Densification

The third option proposes a radical impact in quantity and quality: the renewal and densification of all the resettlement communities. The transformation of all the resettlement communities requires a general citywide plan of interventions with priorities and phases. It implies social, environmental, and economic costs, but if all the resettlement villages in Suzhou were densified, for example, by duplicating the floor area ratio, it would accommodate 1 million people, which is a very relevant contribution to the existing stock considering that the growth of the population of the city over the past 5 years was 2.16 million people. In a strategic approach, the new FAR is advisable to be higher than double the existing one, as in the Nanhuan New Village case, which was increased by three times. In fact, replacing the existing buildings, which were modern when the first inhabitants arrived, but today are, or soon will be, middle-class, goes along with the challenge of the definition and implementation of a new standard of residential environment promoted by the state. What was good enough for just resettled people was decided when the resettlement operations started, so it should not be repeated when new conditions emerge.

The large investment needed for the replacement must increase the number of people in the same area but also:

- Enhance the open spaces in quantity and quality: given the small and scattered green-blue spaces in the existing communities and the surrounding areas, the action of densification should re-design these resources, so that they can also play a role in fulfilling the needs of the interaction of the community. The plan will consider the contribution of the open spaces to the thermal and light comfort and to mitigate the heat island effect;
- Realize an integrated transportation system, integrating public transport, pedestrian and cycling lanes, and car parking places connected to the pedestrian and bike network; limit the extension of the road network; and improve the accessibility to the compounds with a more permeable system of gates;
- Diversify the units to match the needs and preferences of the different households and new lifestyles; diversify the housing types: higher density housing does not always require high-rise developments;
- Mix land use to create an attractive street life;
- Implement the "sponge city" guidelines for rainwater retention and water purification [100] and include systems for saving and producing renewable energy (Figure 4d).
- Obviously, in addition to these specific improvements, the capacity of infrastructures, utilities, and public services will be increased according to the quantity of residents and users.

6. Conclusions

In the conditions of a growing urban population, the intensity of land use is an essential planning decision in promoting environmental sustainability. Chinese local governments are increasingly encouraging compact and mixed-used developments mainly to maximize land revenues and capture commercial and residential land value [101], but not yet mainly to balance economic interests and sustainability purposes. Still, the planning approach in the country is gradually and steadily shifting towards more sustainable development and a high-quality urban environment. In this process, for enhanced use of resources, the renewal of some built areas that do not perform efficiently can be considered. In this direction, the Chinese central government has promoted the regeneration and renewal of what was built before 2000, which is a massive undertaking if the whole country is considered.

This research explored the opportunity of regeneration with densification of what is already built in Suzhou to diminish the consumption of agricultural land and offer a better living environment than what was realized in the early years of massive urbanization. The research concluded that some resettlement communities could be appropriate sites for renewal. In fact, these communities in Suzhou are quickly deteriorating and offer inadequate services and poor housing conditions if the increased wealth of the population is considered, and more so if the actions for further improving the living conditions the government is working on are successful.

This research found that the densification of the resettlement communities can significantly impact the intensification of land use in the whole of Suzhou, given the large number of such communities and their low or medium floor area ratios. The densification project should be site specific, but a general citywide plan of interventions should be drafted with priorities and phases. Densification should be promoted, especially in the resettlement communities with low FAR and good transport capacity and accessibility. The local government should encourage dense and compact development and should have explicit goals to be respected by every development project; specifically, which option of densification is feasible and most suitable for each condition must be decided on a case-by-case basis.

Urban regeneration is costly and the reconstruction itself uses resources, but it can be convenient for the local government because it concerns already urbanized areas. Therefore, it does not occupy agricultural land or consume the land development quotas that the central governments allocate to the local governments. In addition, the increased renewal density contributes to the economic sustainability of the transformation because it can generate sufficient funds for the renewal itself and the compensation of the inhabitants, similar to what has already been experimented with as an example in the renewal of the urban villages in Guangdong [102].

The goal of the transformations with densification analyzed and proposed in this research is not gentrification, profit, or revenue maximization [84,85] but another step in improving the built environment and land value appreciation, benefits that can be shared with the current inhabitants.

7. Limitations

The article has some limitations. Firstly, the main one is the quality and accuracy of the GIS data: in fact, it is often difficult to obtain comprehensive and reliable data for research from public institutions and authorities in China. The research targets resettlement communities in Suzhou, but data are fragmented, not homogeneous and only partially available, so the authors created one dataset *ad hoc* starting from the dataset available and adding what is missing according to various direct and indirect sources.

Secondly, China's current urbanization rate reached 65.22% in 2022 and large-scale construction is slowing down, leading to a slowdown in the densification process in most regions. It is still unclear whether the densification scenarios proposed in this article could also be applied to areas with less-developed economic growth. In future research, we will try to address these limitations.

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Assessment of the Adaptive Reuse Potentiality of Industrial Heritage Based on Improved Entropy TOPSIS Method from the Perspective of Urban Regeneration

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Abstract: In recent years, it has become critical to promote urban redevelopment and maximize the potentiality of industrial heritage through adaptive reuse. Research on the assessment of adaptive reuse potentiality helps to make scientific decisions in sustainable development and the strategy for utilizing industrial heritage. The purpose of this paper is to provide a comprehensive overview of the research on the potentiality of buildings or sites. It also constructs a system for the assessment of adaptive reuse potentiality in industrial heritage and describes the characteristics of different dimensions in the indicators of potentiality evaluation. Utilizing the Improved Entropy Technique for Ordering Preferences by Similarity to the Ideal Solution (Improved Entropy TOPSIS), the relative values of the reuse potentiality of each hierarchical evaluation index are calculated, and an adaptive reuse potentiality ranking of various industrial parks is determined. Through the calculation and analysis, it is demonstrated that the application of this quantitative method to the industrial heritage potentiality evaluation system is highly applicable. This paper's research framework for adaptive reuse potentiality and empirical findings provides targeted recommendations for determining the reuse potentiality and potential hierarchy of industrial heritage, identifying buildings with a high potential for reuse, and developing adaptive reuse strategies to better direct industrial heritage in urban regeneration.

Keywords: industrial heritage; adaptive reuse potentiality; improved entropy; technique for ordering preferences by similarity to the ideal solution; urban regeneration

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1. Introduction

As a significant component of cultural heritage, industrial heritage preserves the memories of regional and urban development as well as the historical fashions and traits of various nations and regions. Today, the adaptive reuse of industrial heritage has largely replaced demolition and reconstruction. How to maximize the value of industrial heritage while supporting regional and urban transformation and better integrating urban regeneration is a significant topic in the field of heritage conservation. Research on the adaptive reuse of industrial heritage has focused on the study of specific strategies for reuse [1] and heritage value assessment [2]. However, many cases have demonstrated that industrial heritage transformation and utilization strategies frequently rely on value assessment rather than adaptive reuse potential assessment, which does not lead to effective industrial heritage protection, full utilization, or the effective promotion of sustainable urban regeneration. Since more than ten years ago, Beijing has been preserving and reusing its industrial heritage. Numerous studies on actual instances of industrial heritage transformation have been conducted, and specific outcomes have been obtained in the fields of industrial heritage preservation and reuse, as well as value assessment. A thorough potentiality evaluation system that is pertinent, systematic, and useful is lacking in the field of research on the evaluation of reuse opportunities. The prerequisites of and keys to the adaptive reuse of industrial heritage now include how to construct a comprehensive evaluation index system to express the reuse potentiality of industrial heritage and how to thoroughly consider the current situation of industrial heritage.

Figure 1 depicts the research framework of this paper. Research on the potentiality of reusing industrial heritage clarifies the concept definition of reuse potentiality assessment, the selection of an evaluation index system, and quantitative methodologies. The rationale for selecting the indicators for the assessment of adaptive reuse potentiality is provided, and the industrial heritage value assessment system is constructed at various levels of autologous value, retrofitting value, and potential benefit value from the building dimension and urban dimension, respectively. In the literature review and material analysis, quantitative research methodologies for assessing the adaptive reuse potentiality of industrial heritage are included. To improve the scientific and unbiased results of the potentiality evaluation, the comprehensive weights of the evaluation indicators were calculated, and the technique for ordering preferences by similarity to the ideal solution (TOPSIS) was used to determine the relative size of the reuse potentialities of various industrial parks as well as the specific potentiality distribution values of each park, which were included in the method description. Ultimately, the applicability of the evaluation method is demonstrated by assessing the potentialities of eight industrial parks in Beijing, which are included in the evaluation results. The evaluation results provide robust, adaptive guidance for both decision making and the management of industrial heritage restoration. Predicting the timing, purpose, and focus of exploitation, as well as proposing reuse plans for the development of the area, are helpful for industrial heritage parks that have not yet been renovated; for those that have been renovated and are currently in use, the potential values and distribution are clarified, as are suggestions for optimizing the current renovation and operational management. This discussion and conclusion comprise this part.

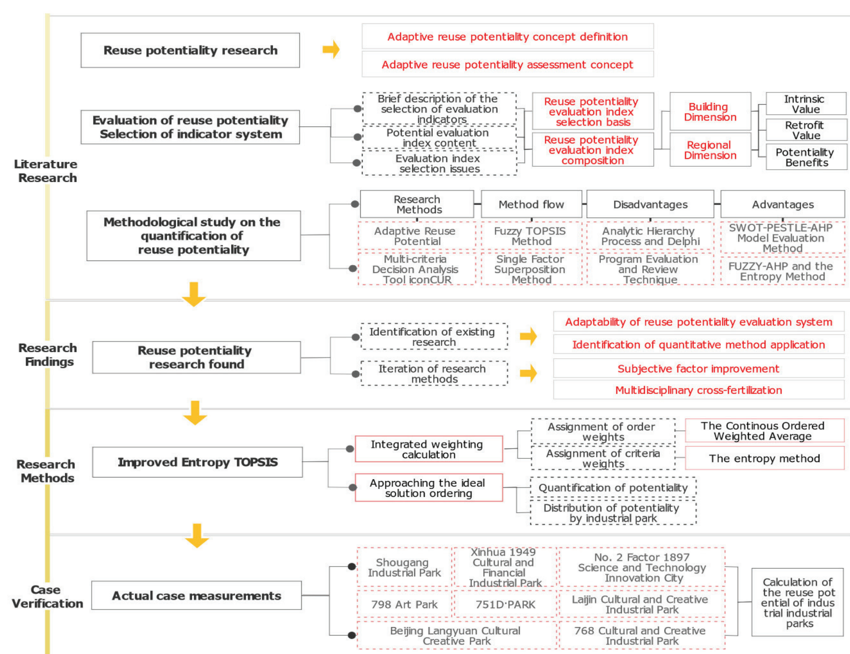


Figure 1. Diagram of the research framework.

2. Review of the Literature on the Potentiality for the Adaptive Reuse of Industrial Heritage

2.1. Research on Reuse Potentiality

Regarding the urban dimension of reuse potentiality, Gui Jin et al. conducted fundamental theoretical research on the design of spatial redevelopment and spatial conservation models for regional sustainable development, constructing an evaluation hierarchy based on spatial development and conservation [3]. Ana Martinovi et al. have developed a theoretical framework for the integration of social sustainability factors into urban regeneration processes in post-conflict areas, using a bottom-up approach to surveying and interviewing the social perceptions of all pertinent interests to obtain targeted influences on the socially sustainable heritage regeneration of industrial heritage. The importance and viability of including the social component of sustainability in strategies for regenerating cultural resources in post-conflict situations are emphasized [4]. This can be used as a trustworthy reference for identifying an indicator system for the growth of the urban dimension of reuse potentiality. Regarding the ontological dimension of reuse potentiality, Wang Jianguo and Jiang Nan categorized reuse potentiality into four categories, historical and cultural, industrial transformation, functional renewal, and economic benefits, and used this information to develop a reuse potential evaluation system based on the building base environment, building shape, structural equipment, internal space, and economic technology [5]. Vardopoulos, I., considers sustainable development potentiality, which implies the realization of benefits when adapting, including physical–economic, functional, environmental, political–social, and cultural potential, and adaptive reuse potential assessment, which focuses more on conservation and sustainable development strategies and provides recommendations on whether to engage in adaptive reuse and the priority of adaptive reuse for the target of the assessment [6]. Wijesiri, W.M.M., on the other hand, recently proposed the concept of the Green Adaptive Reuse (GAR) of buildings as an effective strategy to extend the life of facilities and reduce their carbon footprint, contributing to the preservation of an important heritage that determines cultural development [7] by following and extending Craig Langston's evaluation system and employing it to construct a GAR model to determine the potential for reuse of existing resources [8]. Regarding the potentiality for the reuse of industrial building heritage, Craig Langston predicts buildings' service lives based on the potential obsolescence of physical, economic, functional, technical, social, and legal criteria, guides design strategies by assessing the potentiality to enable building retrofitting to maximize adaptive reuse potential, and verifies the size and ranking of the adaptive reuse potential using the adapt STAR model [9]. This method combines the development of the adaptive reuse of old buildings with the objective of reducing the environmental impact of climate change and contributing to greater energy and resource efficiencies. Fan Shengjun summarized the potentiality evaluation system, which included architectural integrity, locational value, historical continuity, future profitability, and environmental friendliness, based on future value characteristics that reflect recycling potential [10].

The existing system of indicators for assessing reuse potentiality is proposed without providing a foundation for determining the indicators. The majority of value evaluation systems are carried forward from previous generations, resulting in insufficient adaptation to the specificity of industrial heritage for adaptive reuse. The interaction of the evaluation elements' opinions has not been considered. The reuse potentiality derived from the evaluation index system has a relatively limited scope of application and only applies to a specific area of a single industrial building, thereby lacking the relevance and generalizability necessary to guide the renovation strategy. In addition, research on reuse potentiality is more focused on heritage ontology, and the evaluation system does not completely account for the impact of adaptive reuse on the urban environment. To assess the adaptive potential of industrial heritage, the scope of the index system must be expanded to include not only individual industrial buildings but also their location, the surrounding area, and urban regeneration development.

2.2. Research on Quantitative Methods for Reuse Potentiality

The majority of existing studies on the preservation and reuse of industrial heritage adopt a qualitative approach. Due to the overuse of experience-based rules, subjective factors have a significant influence on outcomes and lack support from scientific theory. In recent years, the use of quantitative methods in industrial heritage research has increased due to the development of big data in the field of heritage conservation and the need for precise and scientific research. They are primarily used for assessing the reuse value of industrial heritage, risk analysis, and post-reuse evaluation, but quantitative research methods on reuse potentiality are scarce. The research on reuse potentiality should enhance the accuracy and applicability of predictions as well as build an adaptable potentiality evaluation system that can be utilized at various phases of industrial heritage preservation.

The most common quantitative methods for assessing the potentiality of industrial heritage are listed below. Although Adaptive Reuse Potential (ARP) is effective at estimating the remaining life of buildings and facilitating the analysis and comparison of various reuse objects, the physical life degradation of buildings cannot be precisely calculated, resulting in ambiguous potential evaluation results. The Single Factor Superposition Method simplifies the assessment factors based on quantification and operability principles, and the calculation procedure is more reproducible; however, it is more difficult to obtain assessment parameters and data [11]. Although the data obtained by aggregating and quantifying subjective and objective judgments using the Analytic Hierarchy Process (AHP) and Delphi method are more scientific, subjective factors also influence the variables and corresponding weights [12]. ELimination Et Choix Traduisant la REalité (ELECTRE) has a clearer concept of the superiority of decision options, which can improve decision accuracy, but the method for determining the weights does not take into account the influence of the interaction between the attributes of the indicators on the evaluation results [13]. It is difficult to assess multiple factors at various layers, making the decision outcome uncertain and making it difficult to implement complex decisions regarding reuse potentiality. The VIse Kriterijumski Optimizacioni Racun (VIKOR) ranking process compares group utility values and combined utility values to determine the merits of the evaluation options [14]. Individual high evaluation indicators, when applied to a system of evaluation indicators, can easily trump certain low evaluation indicators, which are also crucial for determining the potentiality of heritage reuse.

To minimize the influence of subjective factors on the evaluation system's results, it is necessary to determine the optimal ranking of the relative magnitudes of the reuse potentialities for multiple options. After combining several multi-attribute decision methods, the Technique for Ordering Preferences by Similarity to the Ideal Solution (TOPSIS) was finally used to determine the relative magnitudes and ranking of the reuse potentialities. The TOPSIS method is a sequential selection technique based on the similarity of ideal targets. The normalized data normalization matrix is used to identify the optimal and inferior targets among multiple targets. The proximity of each evaluation objective to the ideal is determined by separately calculating the distance between each objective and the positive and negative ideal solutions. The objectives are ranked by their magnitudes, and this is used as the basis for evaluating their superiority. The method is suitable for determining the magnitude of the reuse potential by comparing the ranking after calculating the weight of the multi-objective method, which enables a more objective assessment of the reuse potentialities of multiple options and provides decision-makers with targeted guidance. It is unaffected by the order of evaluation options, is suitable for the cross-sectional comparison of multiple evaluation options, is easier when handling fuzzy data, is simpler to calculate, and produces more objective quantitative results. Due to the indicator system's strong reliance on weight, it is easily influenced by the subjective factors of decision-makers, and different weighting schemes appear inconsistent for decision results, so it is more important for the calculation of indicator weights in use. In this paper, we calculate the comprehensive weight of the evaluation index system using the Continuous Ordered Weighted Averaging operator (C-OWA) and the Entropy Weight Method. C-OWA is appropriate for uncertain multi-attribute decisions for which the attribute weights are known with certainty and the attribute values are given as interval numbers in order to reduce the subjective factors of the evaluator and the extreme values of the evaluation data on the calculation errors of the indicator weights and to take into account the influence of the indicator factors in the order. The method was used to calculate the weight of the graded order of the evaluation indicators for reuse potentiality. The Entropy Weight Method is a quantitative method of objective weighting in which the entropy value is used to determine the dispersion of an indicator and the information entropy is used to calculate the weight of each indicator. The entropy weight is modified according to each indicator so as to obtain a more accurate and scientific weighting of the grading criteria indicators. Finally, the comprehensive weights are obtained by linear weighting. The calculation of the comprehensive weight contributes to the improvement of the scientific nature and accuracy of a multi-objective decision analysis, and the evaluation process is more operable and appropriate for the processing and analysis of quantitative data within a multi-layer potentiality evaluation system. Improved entropy TOPSIS enables an objective evaluation of the evaluation object and circumvents the issue in which the solution closest to the ideal solution is also clear to the negative ideal solution. The objective comprehensive assignment based on the determination of order and criterion weights increases the comparative analysis between evaluation indicators, and the combined use of the two methods can improve the scientific and rational nature of the evaluation results, significantly reducing the subjectivity of the results calculated by inviting experts to score the conventional TOPSIS method.

3. Materials and Methods

3.1. Analysis of Adaptive Reuse Potentiality of Industrial Heritage

Definition of Adaptive Reuse Potentiality and Its Assessment of Industrial Heritage

The former scholars defined architecture reuse potentiality as a capacity that needs to be stimulated externally and provides practical benefits [15], a capacity that contains the possibility of reuse hidden in itself and any intervention capacity to adapt to new conditions [16], which represents the potentiality for future transformation and the sustainability of the project after renovation. This paper defines the adaptive reuse potentiality of industrial heritage as the ability of the heritage to contribute to its own and to the city's sustainable development by providing practical benefits to subsequent development. This potentiality can be reflected in three dimensions: autologous value, retrofitting value, and potential benefit value. The first represents the potentiality for the industrial heritage to be reused, the second represents the potential ability for efficient use after reuse, and the third represents the potential ability for retrofitting to bring actual benefits to the region or city.

3.2. Selection of the Evaluation Index

3.2.1. Potentiality Evaluation Index Selection Basis

Previous assessments of reuse potentiality have focused predominantly on transformation potentiality based on heritage value indicators, with a greater emphasis on the value of industrial heritage ontology [17–19]. The future value-added effect and its impact on the city were not fully accounted for in the evaluation index system, and the existing potentiality assessment indexes do not differentiate the relationship between the heritage essence and urban redevelopment due to the indexes' lack of relevance and adaptability [20,21], as well as an insufficient consideration for the complexity and diversity of industrial heritage transformation [22]. To emphasize the significance of urban indicators, the selected evaluation indicators emphasize the need to promote healthier and more efficient urban renewal [23,24]. Thus, this paper discusses adaptive reuse potentiality from three perspectives: autologous value, retrofitting value, and potential benefit value. Not only is the building itself discussed but the selection of urban dimension indicators also needs to be included.

This paper examines an index system for evaluating the reuse potentiality of industrial heritage, using industrial heritage as the research object and constructing three progressive relationship levels to address the existing problems of the potential evaluation system. The first dimension is autologous value, which represents an object's inherent value regardless of whether it has been renovated or not, and its own value, which exists objectively regardless of renovation or not and is used to determine whether renovation and reuse can be performed based on the evaluation results. The second dimension is retrofitting value, which represents the increase in use value resulting from renovation; the higher the rating, the greater the effect of subsequent renovation and use. The third dimension of future benefit represents the impact of the adaptive reuse of industrial heritage on surrounding areas and cities, which can help accelerate urban development.

In order to make the potentiality evaluation results more scientific for guiding the renovation and adaptive reuse strategies, the potentiality assessment results are presented as weighted scores of the three dimensions, and the corresponding reuse strategy cannot determine the reuse potentiality of industrial heritage solely based on the final score but should consider the weights of different levels and further clarify the tendency and trend of reuse based on the specific score. To develop a targeted redevelopment plan, we should consider the weighting of various indicators and elucidate the reuse tendency and trend based on the specific score and weight distribution of each dimension.

3.2.2. Reuse Potentiality Evaluation Index Composition

Figure 2 illustrates how the assessment indexes of the adaptive reuse potentiality of industrial heritage are calculated, as well as how the evaluation content is separated into autologous value, retrofitting value, and potential benefit value. There are two components to the assessment of industrial heritage: the building dimension and the urban dimension. The evaluation index of the autologous value comprises the landscape integrity, structural reliability, heritage authenticity, safety in the autologous dimension and location, the surrounding environment, external space, planning restrictions, and infrastructure in the regional dimension. The evaluation indexes of the retrofitting value include the functional variability, architectural sustainability, user attitude, and construction technology implementation. The evaluation indexes of the retrofitting value include the expected effect, functional variability, architectural sustainability, user attitude, construction technology implementation, and expected effect. In the urban dimension, the evaluation indexes of the retrofitting value include the economic conditions, political context, participants' attitudes, and legal policies. The potential effect evaluation indexes include the humanistic value, artistic value, expected impact, scientific and technological value, the representativeness and scarcity of the building ontology dimension, the historical continuity, the cultural evaluation parameters of the indicators, and data acquisition that is challenging, resulting in the variables and weights being influenced by subjective factors.

The evaluation of the adaptive reuse potentiality of industrial heritage is a complicated process that depends on many factors. Using a singular evaluation index to evaluate the reuse potentiality of various options could result in less precise evaluation results. Due to the fact that the three-dimensional indicators for various industrial heritage need to be modified in a targeted manner, they are only partially enumerated in the examples, and the specific contents of the indicators need to be modified for various research topics.

3.2.3. Overview Section of the Research Area

In China, the city of Beijing was early in carrying out practices of industrial heritage conservation and reuse, and it has taken the lead in conducting a census and academic research on industrial heritage. From the announcement of 30 existing industrial heritage sites in Beijing by the Architectural Society of China's Academic Committee on Industrial Architectural Heritage in 2010 to the first batch of China's Industrial Heritage Protection List in 2019, 9 industrial heritage sites in Beijing were selected [25]. The preservation and reuse of Beijing's industrial heritage are becoming more important. Beijing's existing urban industrial heritage can be divided into nine national, six municipal, and several general industrial heritage sites, totaling 2500 hectares and generally possessing multiple groups of architectural monuments.

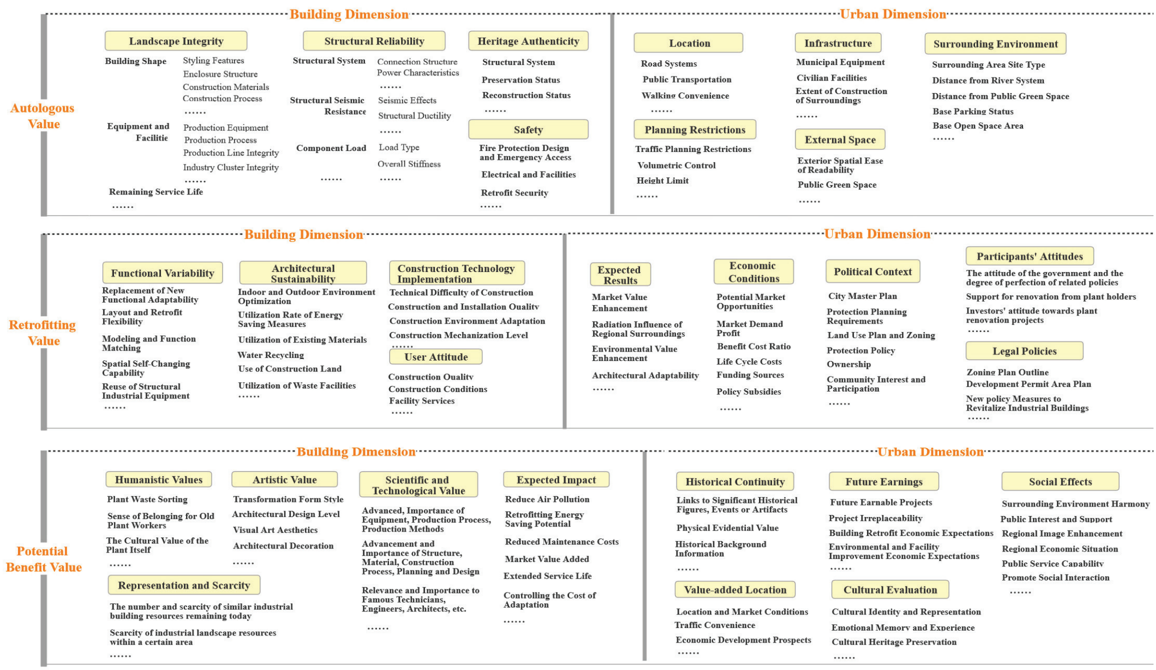


Figure 2. Industrial heritage reuse evaluation system indicators.

Although Beijing has made some progress in the preservation of industrial heritage, a large number of industrial buildings and structures are still inevitably demolished and severely damaged during urban construction. Due to their advantageous location and low demolition costs, a large number of industrial buildings and structures in Beijing's older urban areas have been demolished [26]. In addition, there is a lack of rational and scientific development and utilization of industrial heritage, as well as a lack of policy guidance for the reuse of individual industrial heritage properties, resulting in a uniform pattern of reuse and imitation. The reuse of industrial heritage must be developed appropriately, taking into consideration its own potential for adaptive reuse and the actual urban development situation [27].

This paper selects the first group of eight representative and typical parks, including Shougang Industrial Heritage Park and 798 Art Park, which Beijing announced in January 2019 as cultural and creative industrial parks transformed from industrial architecture heritage. They have multiple building clusters, are close in scale, contribute significantly to the development of Beijing's cultural industries through adaptive reuse, and best represent Beijing's industrial architecture heritage conservation in its current state. Figure 3 illustrates the distribution of the parks' locations. They are currently employed as evaluation objects for measuring and verifying the potential for reuse of industrial architecture heritage.

3.3. Calculation of Reuse Potentiality Based on Improved Entropy TOPSIS

The quantitative measurement of reuse potential usually begins by assigning weights to the evaluation indicator system, including criteria weights and order weights. Based on the linearly weighted composite weights, the reuse potential size is compared via ranking after the composite potential evaluation value is calculated based on the indicator weights using Improved Entropy TOPSIS [28].

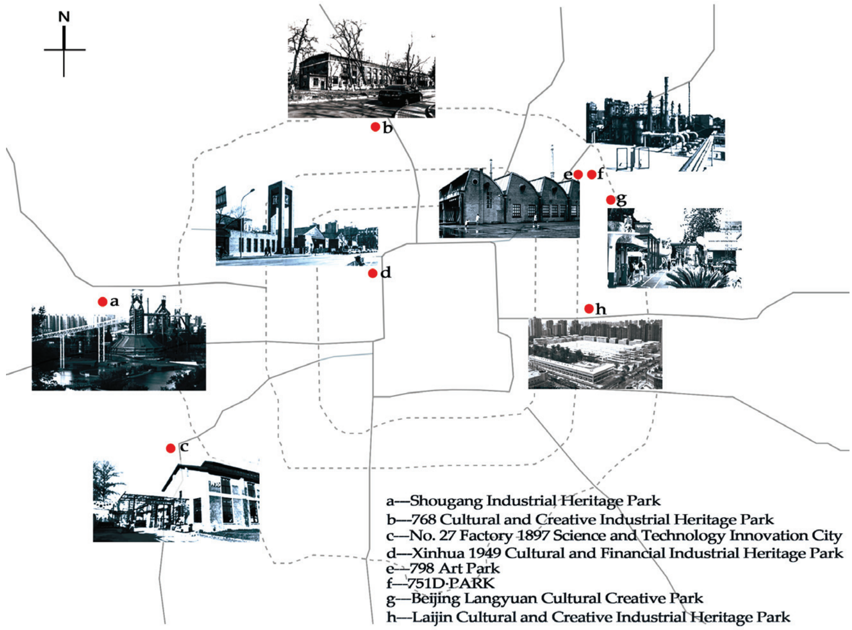


Figure 3. Distribution of industrial parks' locations.

3.3.1. Combined Weighting of Indicators

Assignment of Order Weights

The C-OWA method was used to calculate the order weights of the reuse potential evaluation indicators. The specific calculation steps are as follows:

1. A number of expert groups were invited to score the importance of the indicators according to the existing evaluation system. Scoring set A for the original indicators of the re-evaluation program was obtained.

$$\mathrm{A} = (a_1,\ a_2,\ \ldots\ ,\ a_n)$$

2. The new importance scores were obtained by arranging the scored data from the largest to the smallest to obtain the evaluation set B:

$$\mathrm{B} = (b_0,\ b_1,\ \ldots\ ,\ b_{n-1})\ (b_0 \geq\ b_1 \geq\ \ldots \geq\ b_{n-1})$$

3. The weighting vector φ_{m+1} for each value in the evaluation index was determined based on the combination number C_{n-1}^{m}:

$$\varphi_{m+1} = \frac{C_{n-1}^{m}}{\sum\limits_{m=0}^{n-1} C_{n-1}^{m}} = \frac{C_{n-1}^{m}}{2^{n-1}}, \tag{1}$$

$$m = 0,\ 1,\ \ldots,\ l-1\ \ \sum_{m=0}^{n-1} \varphi_{m+1} = 1.$$

4. Set B of the importance scores of the evaluation indicators was weighted to obtain the absolute weight $\overline{\vartheta_j}$:

$$\overline{\vartheta_j} = \sum_{m=0}^{n-1} \varphi_{m+1} b_m (j = 1,\ 2,\ \ldots, n) \tag{2}$$

5. The relative weights of the evaluation indicators ϑ_j were calculated:.

$$\vartheta_j = \frac{\overline{\vartheta_j}}{\sum_{j=0}^{p} \overline{\vartheta_j}} (j = 1,\ 2,\ \ldots, n) \tag{3}$$

Assignment of Criteria Weights

The Entropy Weight Method was used to calculate the criteria weights of the reuse potential evaluation indicators. The specific calculation steps are as follows:

1. The corresponding values of different program indicators a_{ij} were determined, and they were homogenized according to the available expert importance evaluation scoring data to avoid the influence of different levels of evaluation indicators:

$$a'_{ij} = \frac{a_{ij} - \min(a_{ij}, \ldots, a_{mj})}{\max\{a_{ij}, \ldots, a_{mj}\} - \min\{a_{ij}, \ldots, a_{mj}\}} (i = 1, \ldots, m\ j = 1, \ldots, n) \tag{4}$$

2. The weight of the different evaluation values of each indicator in the total value δ_{ij} were calculated:

$$\delta_{ij} = \frac{a'_{ij}}{\sum_{i=1}^{m} a'_{ij}} (i = 1, \ldots, m\ j = 1, \ldots, n) \tag{5}$$

3. The entropy of each indicator e_j was calculated:

$$e_j = -\mathrm{k} \sum_{i=1}^{m} \delta_{ij} \ln(\delta_{ij}) (i = 1, \ldots, m\ j = 1, \ldots, n) \tag{6}$$

4. The information entropy redundancy of each indicator d_j was calculated:

$$d_j = 1 - e_j \tag{7}$$

5. The weights of the graded indicators μ_j were calculated:

$$\mu_j = \frac{d_j}{\sum_{i=1}^{n} d_j} (j = 1, \ldots, n) \tag{8}$$

Determination of Comprehensive Weights

In order to avoid the negative influence of a single weight on the calculation of the evaluation indexes, the comprehensive weights must consider both the relative importance of the indexes and the influence of the index factors in the order of the evaluation results. The criteria weights and the order weights must be linearly weighted to obtain the comprehensive weights ω_j.

$$\omega_j = \alpha\mu_j + (1 - \alpha)\vartheta_j \quad \alpha \in [0, 1], \tag{9}$$

$$\omega_j \geq 0 \sum_{j=1}^{n} \omega_j = 1. \tag{10}$$

3.3.2. Determination of the Reuse Adaptive Potentiality Using TOPSIS Method

The exact calculation procedure is as follows:

1. The standardization of the indicator data was determined according to the development of the evaluation indicators' scoring level criteria, the actual observation to obtain the quantitative indicator value, the expert scoring to achieve the quantitative qualitative indicators, and the evaluation value of x_{ij}. Then the attributes of each indicator are uniformly varied to the range of (0, 1), using the normalization process of the function mat2gray in matble data processing software, which is more convenient for obtaining the normalized evaluation value x'_{ij}.
2. A weighted decision matrix Z was constructed based on the normalized evaluation values:

$$z_{ij} = \omega_{ij} x'_{ij},$$

$$Z = \begin{bmatrix} z_{11} & \cdots & z_{1j} \\ \vdots & \ddots & \vdots \\ z_{i1} & \cdots & z_{ij} \end{bmatrix}. \tag{11}$$

3. The optimal evaluation value for each evaluation scenario was determined as a positive ideal solution z^{+}, and the worst evaluation value was determined as a negative ideal solution z^{-}:

$$z^{+} = [z_{i1}^{+}, z_{i2}^{+}, \ldots, z_{ij}^{+}](j = 1, 2, \ldots, n),$$

$$z^{-} = [z_{i1}^{-}, z_{i2}^{-}, \ldots, z_{ij}^{-}](j = 1, 2, \ldots, n).$$

4. the Euclidean distance, the distance to the optimal solution D_i^{+}, and the distance to the worst value D_i^{-} were calculated:

$$D_i^{+} = \sqrt{\sum_{j=1}^{n}\left(z_{ij}^{+} - z_{ij}\right)^2}(i = 1, 2, \ldots, m \;\; j = 1, 2, \ldots, n), \tag{12}$$

$$D_i^{-} = \sqrt{\sum_{j=1}^{n}\left(z_{ij}^{-} - z_{ij}\right)^2}(i = 1, 2, \ldots, m \;\; j = 1, 2, \ldots, n). \tag{13}$$

5. The relative proximities C_i^{*} of each evaluation option to the optimum value and rank were calculated and compared to determine the size of the recycling potentiality;

$$C_i^{*} = \frac{D_i^{-}}{D_i^{+} + D_i^{-}} \quad 0 \le C_i^{*} \le 1(i = 1, 2, \ldots, m) \tag{14}$$

The closer the value of the relative proximity C_i^{*} is to 1, the more effective the corresponding solution is and the greater the reuse potentiality is.

4. Calculation

The specific reuse potential calculations have been omitted due to space limitations, and the results are presented in table form. The building evaluation process is as follows:

1. The evaluation criteria were developed using empirical data and industry norms, as well as the specific indicator content of the reuse potential evaluation system, and experts scored the importance using the evaluation criteria, as shown in Table 1.

Table 1. Evaluation index importance scoring basis.

Evaluation Index importance Level Classification and Corresponding Score					
Level Classification	Absolutely Important	Very Important	More Important	Important	Normal
Corresponding Score	10.0–8.0	8.0–6.0	6.0–4.0	4.0–2.0	2.0–0.0

2. The Continuous Ordered Weighted Average (C-OWA) operator and entropy weighting method were used to calculate the order weights and criteria weights of the secondary indexes, respectively, and the comprehensive weight is determined via linear weighting, as shown in Table 2 and Figure 4;
3. The scoring was based on the characteristics and actual conditions of the different industrial heritage parks, and the indicator data was standardized, as shown in Table 3a,b;

Table 2. Combined weighting calculation results.

Evaluation Indicator System		Weighting Calculation							
Primary Indicators	Secondary Indicator	Importance Scoring					Order Weights ϑ_j	Criteria Weights μ_j	Integrated Weights ω_j
		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5			
Intrinsic Value (Building Dimension)	Landscape Integrity	8.5	8.0	9.0	8.5	8.0	0.0377	0.019	0.0284
	Structural Reliability	9.0	8.5	9.5	8.5	7.5	0.0388	0.044	0.0414
	Heritage Authenticity	8.5	6.5	7.5	7.0	8.0	0.0338	0.025	0.0294
	Safety	9.5	9.0	8.5	8.0	9.0	0.0398	0.043	0.0414
Intrinsic Value (Regional Dimension)	Location	8.2	8.0	7.5	6.5	7.8	0.0348	0.041	0.0379
	Surrounding Environment	7.0	7.3	8.5	6.5	8.0	0.0334	0.019	0.0262
	External Space	6.5	6.0	7.5	7.0	8.5	0.0317	0.044	0.0379
	Planning Restrictions	8.5	8.0	7.5	7.0	9.0	0.0360	0.025	0.0305
	Infrastructure	7.5	8.5	8.0	7.5	9.0	0.0362	0.043	0.0396
Retrofit Value (Building Dimension)	Functional Variability	6.5	7.5	8.0	8.5	8.0	0.0352	0.021	0.0281
	Architectural Sustainability	5.5	6.5	7.0	6.5	7.0	0.0297	0.021	0.0254
	User Attitude	7.8	7.5	6.5	4.5	8.0	0.0323	0.041	0.0367
	Construction Technology Implementation	7.0	8.5	9.0	7.5	7.5	0.0352	0.042	0.0386
Retrofit Value (Regional Dimension)	Expected Results	8.5	8.0	7.5	8.5	9.0	0.0376	0.046	0.0418
	Economic Conditions	9.5	9.0	8.0	8.5	7.5	0.0383	0.025	0.0317
	Political Context	7.0	6.5	7.5	8.0	8.5	0.0338	0.040	0.0369
	Participants′ Attitudes	7.0	7.5	8.5	7,0	7.5	0.0334	0.021	0.0272
	Legal Policies	8.5	8.0	9.0	9.5	8.5	0.0390	0.021	0.0300
Potential Benefits (Building Dimension)	Humanistic Values	7.5	7.0	7.5	8.5	8.0	0.0345	0.041	0.0400
	Artistic Value	7.5	7.0	8.0	8.5	8.5	0.0359	0.042	0.0390
	Expected Impact	9.0	9.5	8.5	8.0	8.5	0.0390	0.046	0.0425
	Scientific and Technological Value	7.5	7.0	6.5	7.5	8.0	0.0331	0.051	0.0421
	Representation and Scarcity	8.0	8.5	9.0	8.5	9.5	0.0390	0.041	0.0400
Potential Benefits (Regional Dimension)	History Continuity	5.5	6.5	7.0	7.5	7.5	0.0312	0.040	0.0356
	Cultural Evaluation	9.5	9.0	8.5	8.0	9.0	0.0398	0.031	0.0354
	Social Effects	8.0	8.5	7.5	7.0	8.0	0.0353	0.058	0.0467
	Value-added Location	7.5	8.5	8.0	8.5	7.0	0.0359	0.031	0.0335
	Future Earnings	9.5	9.0	8.5	9.0	8.0	0.0398	0.034	0.0369

Table 3. Standardization of indicator evaluation data.

(a)

Evaluation Indicator System		Campus Case Measurement							
Primary Indicators	**Secondary Indicator**	**Shougang Industrial Park**		**751D·PARK**		**No. 27 Factory 1897 Science and Technology Innovation City**		**Laijin Cultural and Creative Industrial Park**	
		Weighted Data		**Weighted Data**		**Weighted Data**		**Weighted Data**	
Intrinsic Value (Building Dimension)	Landscape Integrity	0.0248	0.1215	0.0195	0.1050	0.0178	0.0808	0.0244	0.1056
	Structural Reliability	0.0362		0.0349		0.0107		0.0287	
	Heritage Authenticity	0.0294		0.0156		0.0185		0.0180	
	Safety	0.0311		0.0349		0.0337		0.0345	
Intrinsic Value (Regional Dimension)	Location	0.0142	0.0614	0.0332	0.1049	0.0140	0.1115	0.0242	0.1194
	Surrounding Environment	0.0000		0.0066		0.0116		0.0160	
	External Space	0.0095		0.0308		0.0336		0.0273	
	Planning Restrictions	0.0229		0.0172		0.0169		0.0254	
	Infrastructure	0.0149		0.0173		0.0352		0.0264	
Retrofit Value (Building Dimension)	Functional Variability	0.0246	0.1015	0.0237	0.0951	0.0187	0.0700	0.0250	0.0609
	Architectural Sustainability	0.0158		0.0143		0.0066		0.0183	
	User Attitude	0.0321		0.0367		0.0190		0.0112	
	Construction Technology Implementation	0.0290		0.0205		0.0257		0.0064	
Retrofit Value (Regional Dimension)	Expected Results	0.0334	0.1322	0.0209	0.0657	0.0248	0.1069	0.0000	0.1007
	Economic Conditions	0.0198		0.0000		0.0117		0.0167	
	Political Context	0.0351		0.0115		0.0232		0.0318	
	Participants' Attitudes	0.0177		0.0051		0.0272		0.0272	
	Legal Policies	0.0263		0.0281		0.0200		0.0250	
Potential Benefits (Building Dimension)	Humanistic Values	0.0300	0.1683	0.0100	0.1241	0.0207	0.0933	0.0267	0.1113
	Artistic Value	0.0243		0.0195		0.0231		0.0303	
	Expected Impact	0.0372		0.0345		0.0346		0.0319	
	Scientific and Technological Value	0.0368		0.0276		0.0000		0.0058	
	Representation and Scarcity	0.0400		0.0325		0.0148		0.0167	
Potential Benefits (Regional Dimension)	History Continuity	0.0356	0.1718	0.0189	0.1228	0.0211	0.1279	0.0040	0.0682
	Cultural Evaluation	0.0257		0.0277		0.0328		0.0197	
	Social Effects	0.0420		0.0262		0.0380		0.0233	
	Value-added Location	0.0335		0.0293		0.0223		0.0130	
	Future Earnings	0.0351		0.0208		0.0137		0.0082	

Table 3. *Cont.*

(b)									
Evaluation Indicator System		**Campus Case Measurement**							
Primary Indicators	**Secondary Indicator**	**Xinhua 1949 Cultural and Financial Industrial Park**		**768 Cultural and Creative Industrial Park**		**798 Art Park**		**Beijing Langyuan Cultural Creative Park**	
		Weighted Data		**Weighted Data**		**Weighted Data**		**Weighted Data**	
Intrinsic Value (Building Dimension)	Landscape Integrity	0.0230	0.1009	0.0182	0.0969	0.0258	0.1028	0.0158	0.0814
	Structural Reliability	0.0311		0.0340		0.0113		0.0199	
	Heritage Authenticity	0.0184		0.0210		0.0281		0.0120	
	Safety	0.0285		0.0237		0.0376		0.0337	
Intrinsic Value (Regional Dimension)	Location	0.0237	0.0754	0.0379	0.1149	0.0190	0.1401	0.0182	0.1095
	Surrounding Environment	0.0164		0.0262		0.0250		0.0213	
	External Space	0.0201		0.0162		0.0379		0.0364	
	Planning Restrictions	0.0153		0.0120		0.0277		0.0158	
	Infrastructure	0.0000		0.0226		0.0306		0.0176	
Retrofit Value (Building Dimension)	Functional Variability	0.0176	0.0798	0.0030	0.0444	0.0141	0.0942	0.0219	0.0433
	Architectural Sustainability	0.0174		0.0000		0.0115		0.0038	
	User Attitude	0.0195		0.0262		0.0300		0.0163	
	Construction Technology Implementation	0.0253		0.0152		0.0386		0.0014	
Retrofit Value (Regional Dimension)	Expected Results	0.0340	0.0978	0.0090	0.0599	0.0380	0.1081	0.0046	0.0371
	Economic Conditions	0.0198		0.0181		0.0058		0.0047	
	Political Context	0.0196		0.0171		0.0185		0.0014	
	Participants' Attitudes	0.0170		0.0029		0.0173		0.0131	
	Legal Policies	0.0075		0.0129		0.0286		0.0133	
Potential Benefits (Building Dimension)	Humanistic Values	0.0263	0.0526	0.0171	0.0701	0.0273	0.1200	0.0059	0.0805
	Artistic Value	0.0122		0.0042		0.0159		0.0159	
	Expected Impact	0.0080		0.0121		0.0367		0.0000	
	Scientific and Technological Value	0.0000		0.0195		0.0401		0.0187	
	Representation and Scarcity	0.0063		0.0171		0.0000		0.0400	
Potential Benefits (Regional Dimension)	History Continuity	0.0200	0.1095	0.0203	0.1411	0.0178	0.1293	0.0158	0.1041
	Cultural Evaluation	0.0354		0.0278		0.0338		0.0170	
	Social Effects	0.0379		0.0467		0.0424		0.0415	
	Value-added Location	0.0105		0.0239		0.0152		0.0161	
	Future Earnings	0.0058		0.0224		0.0201		0.0137	

4. The relative size of the reuse potential was obtained by calculating the relative proximity C_i^* according to the TOPSIS method, and the final potentiality ranking is shown in Table 4.

Table 4. TOPSIS evaluation calculation results.

Item	Positive Ideal Solution Distance D_i^+	Negative Ideal Solution Distance D_i^-	Relative Proximity C_i^*	Sort Results
Shougang Industrial Heritage Park	0.294	0.627	0.681	1
798 Art Park	0.347	0.573	0.623	2
751D·PARK	0.375	0.483	0.563	3
No. 27 Factory 1897 Science and Technology Innovation City	0.404	0.466	0.536	4
Laijin Cultural and Creative Industrial Heritage Park	0.471	0.465	0.497	5
768 Cultural and Creative Industrial Heritage Park	0.464	0.401	0.464	6
Xinhua 1949 Cultural and Financial Industrial Heritage Park	0.494	0.397	0.446	7
Beijing Langyuan Cultural Creative Park	0.534	0.368	0.408	8

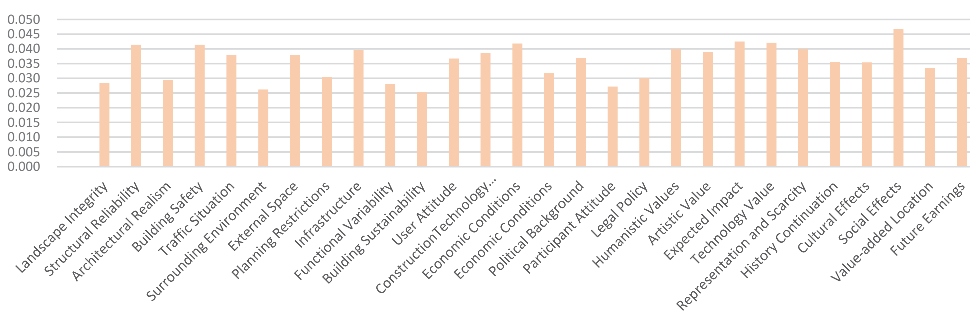


Figure 4. Graphical representation of the integrated weight calculation results.

The potentiality validation step was a continuation of the reuse potential evaluation system, with the combined weights obtained via the linear weighting of the order weights and the criteria weights. Step 3.invited park users to score the secondary evaluation indicators for which the standardization is shown in Tables A1 and A2 in the Appendix A. The TOPSIS method was used to quantify the magnitude of the reuse potential of the eight parks as per the users, as shown in Table A3.

5. Results and Discussion

The calculation results of the relative size ranking of the potential of the eight parks are as follows: Shougang Industrial Heritage Park > 798 Art Park > 751D·PARK > No. 27 Factory 1897 Science and Technology Innovation City > Laijin Cultural and Creative Industry Heritage Park > 768 Cultural and Creative Industry Heritage Park > Xinhua 1949 Cultural and Financial Industry Heritage Park > Beijing Langyuan Cultural Creative Park. The calculation results with respect to the reuse potential from the user's perspective are as follows: Shougang Industrial Heritage Park > 798 Art Park > 751D-PARK > No. 27 Factory 1897 Science and Technology Innovation City > Laijin Cultural and Creative Industrial Park > Xinhua 1949 Cultural and Financial Industrial Heritage Park > 768 Cultural and Creative Industrial Heritage Park > Beijing Langyuan Cultural Creative Park.

According to the radar map derived from the potentiality measurements and evaluation data of the eight parks, the results of the actual measurements and user evaluations in six dimensions, such as building ontology and the urban dimension, for measuring the potential distribution do not differ significantly. The final ranking results of the relative value of the potential size remain unchanged, indicating that the potentiality evaluation system and quantitative measurement procedure are feasible.

The evaluation results indicate that: (1) the potentiality of the regional dimension needs to be taken into account. With the exception of Shougang Industrial Park and 798 Industrial Park, the urban dimension has a greater potential for utilization than the building dimension in the remaining parks. The scarcity of both Shougang Industrial Heritage Park and 798 Art Park increases the value of the building ontology because their distinct designs represent the characteristics of their respective industries. According to the findings, the potentiality value of the regional dimension largely determines the ranking of the final reuse potentialities of industrial parks with less distinct shapes, and the higher the actual measured potential value, the higher the ranking of the industrial park's reuse potentiality. Due to insufficient utilization of the potentiality of the urban dimension, the current paradigm of transformation is rather homogeneous. In order to promote sustainable urban development, it is necessary to devise a targeted industrial heritage reuse strategy that takes the urban dimension into account. (2) These eight successful reuse cases of industrial parks demonstrate that an important prerequisite for the reuse of industrial heritage is that the buildings are objectively adaptable, so structural reliability and architectural safety provide significant advantages in terms of intrinsic value assessment. Furthermore, the expected impact of the building and the social utility of the urban dimension highlight its potentiality value. As the location of industrial heritage will be the new environment for functional use after renewal, the location's potential has a significant impact on the future development of the reuse project. The added-value conditions of the location, such as the anticipated increased impact and the social benefit of the industrial heritage prior to use, are essential in determining the reuse strategy.

798 Art Park was the first industrial heritage park in China to be redeveloped spontaneously without planning; 751 D·PARK was redeveloped through planning; and Shougang Industrial Heritage Park was the largest industrial heritage park to be redeveloped through planning. Due to space limitations, we will briefly discuss the assessment results using the three industrial heritage parks with the greatest potential for reuse and the most representative examples.

Figure 5 depicts the measured results of Shougang Industrial Heritage Park, and the actual measurement is essentially consistent with the results of the user evaluation potential; its reuse potential primarily emphasizes the potentiality value in the building and urban dimension, and the renovation strategy indicates the potential ability to bring actual benefits to the region and the city following adaptive reuse. Most of the buildings and structures in the park have strong industrial characteristics, and their distinctive forms and volumes are highly representative and scarce for the regional and urban environments [29]. To preserve its scientific and technological value, Shougang Industrial Heritage Park must retain a greater number of heritage categories and quantities, as well as several significant process nodes and a large number of surviving muscles, and contribute to the preservation of collective memory [30]. Because it is not in a central location with well-developed urban functions or a commercial environment, the urban dimension's inherent value prior to adaptive use is low.

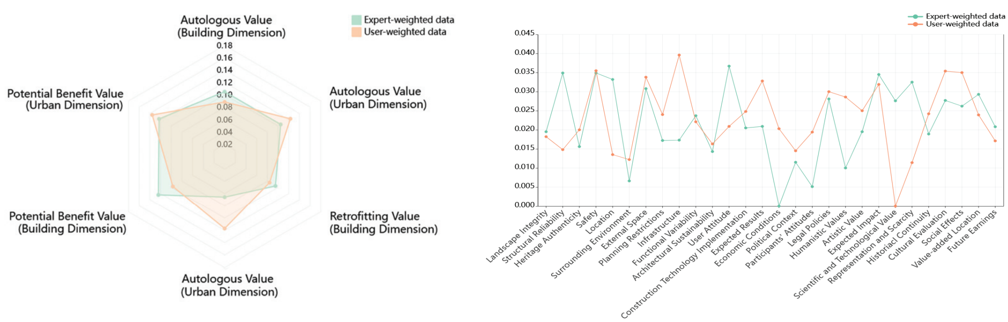
Figure 6 depicts the results of 798 Art Park's evaluation potential. The user evaluation of the urban dimension's autologous value and retrofitting value is less than the actual potential measured potential benefit value, indicating that its renovation brings expectations to the urban area that fall short of the actual predicted potential value. The urban dimension of the park's autologous value is more prominent.

798 Art Park epitomizes the value of art and its driving force. As its adaptive reuse adds new artistic and cultural values to its industrial heritage, it presents rich and diverse cultural values to visitors and provides better artistic experiences through the atmosphere of the art district, resulting in economic value for the area in which it is located [31]. The interior and outdoor space characteristics of the old building are utilized rationally in the building space, and emphasis is placed on the transformation of space. The indoor and

outdoor spaces and flow lines are reorganized so that the spaces form various levels and depths. Nevertheless, according to feedback from actual users, the park's building environment and sanitation facilities are less satisfactory, and the sanitary conditions are more concerning. In addition, because some functions overlap and business introductions are comparable [32], the users' evaluation of the transformation value of the urban dimension is lower than anticipated.

(**a**) (**b**)

Figure 5. Comparison of potential evaluation distribution in Shougang Industrial Heritage Park. (**a**) Distribution of reuse potential of primary indicators; (**b**) distribution of reuse potential for secondary indicators.

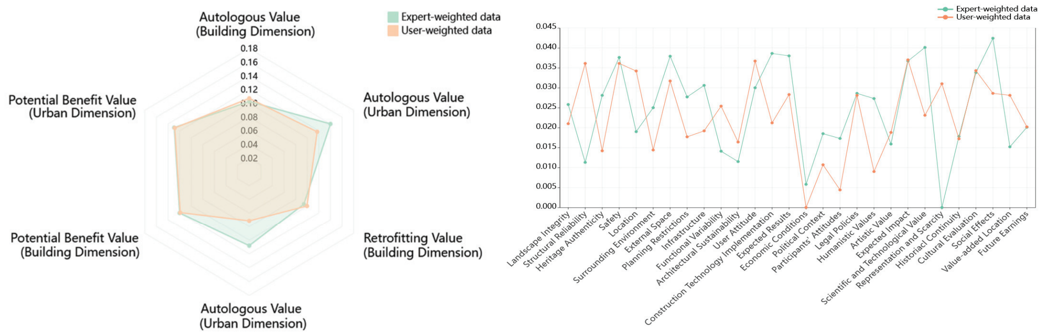


(**a**) (**b**)

Figure 6. Comparison of potential evaluation distribution in 798 Art Park. (**a**) Distribution of reuse potential of primary indicators; (**b**) distribution of reuse potential for secondary indicators.

Figure 7 depicts the potential measurement results for 751D-PARK. The user evaluation has a higher value than the actual measurement potential among the autologous and retrofitting values of the urban dimension, indicating that its renovation has a larger impact on the urban area than the actual predicted potential size. The potential benefits of the urban dimension and the building itself stand out more.

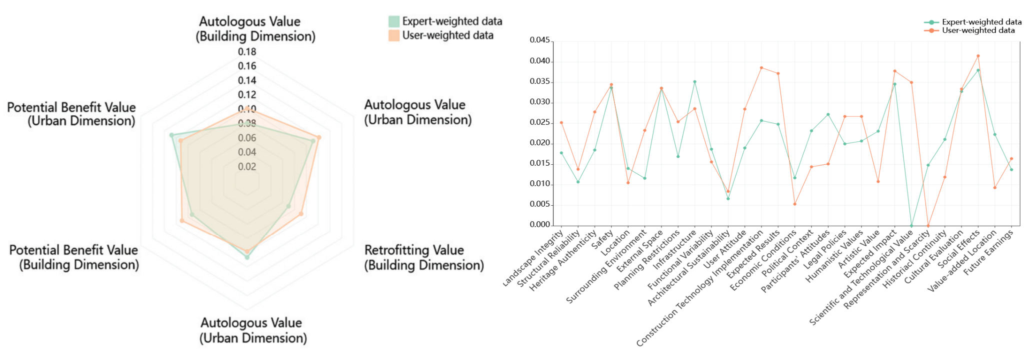
The primary function of 751D-PARK was to ensure the supply of living and production energy for the construction and development of the electronic city. Later, it was transformed into an international cultural and creative park with a fashion design theme, establishing a trading platform for the design industry in the original factory compound and serving as a cultural gathering place for numerous domestic and foreign fashion design groups and well-known companies. The transformed industrial space resources serve as a venue for high-end brand launches and original design exhibitions, and the brand's activities have a far-reaching influence, culminating in an anticipated impact on the urban area that exceeds its actual predicted potential size. The retention of iconic and representative buildings and structures reflects the potential value response for the building proper, and the renovation preserves the original environment, develops new functions, and transforms old industrial equipment into new art spaces, making it an important area for the fusion of fashion and art [33].



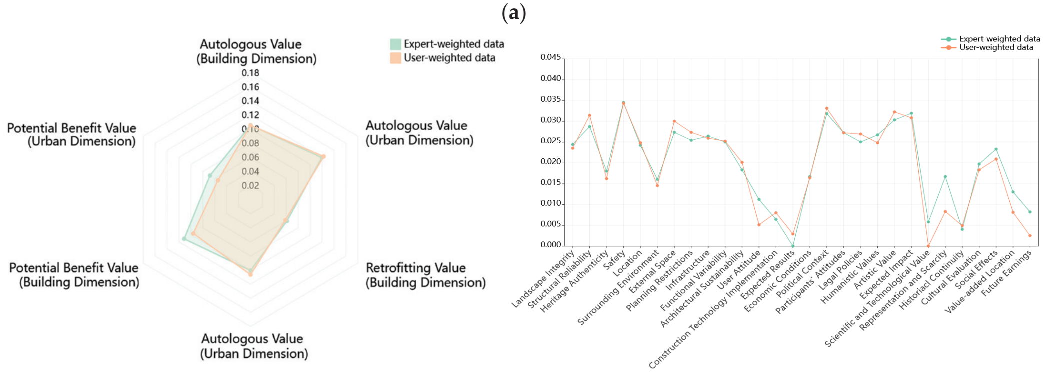
(**a**) (**b**)

Figure 7. Comparison of potential evaluation distribution in 751 D·PARK. (**a**) Distribution of reuse potential of primary indicators; (**b**) distribution of reuse potential for secondary indicators.

The potentiality measurements for the remaining parks are shown in Figure 8.



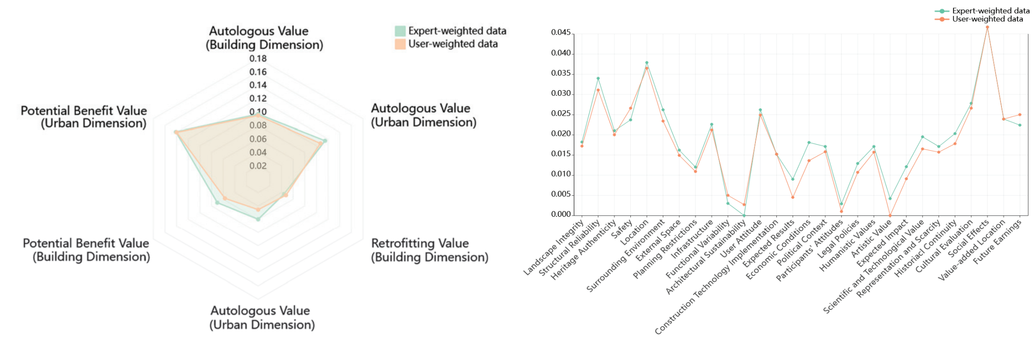
(**a**)



(**b**)

Figure 8. *Cont.*

(**c**)



(**d**)

(**e**)

Figure 8. Comparison of the radar map of the distribution of potential of the remaining industrial heritage parks. (**a**) Distribution of indicators of reuse potential in No. 27 Factory 1897 Science and Technology Innovation City; (**b**) distribution of indicators of reuse potential in Laijin Cultural and Creative Industry Heritage Park; (**c**) distribution of indicators of reuse potential in Xinhua 1949 Cultural and Financial Industrial Heritage Park; (**d**) distribution of indicators of reuse potential in 768 Cultural and Creative Industry Heritage Park; (**e**) distribution of indicators of reuse potential in Beijing Langyuan Cultural Creative Park.

Its evaluation method is more compatible than a conventional reuse potentiality evaluation, and the evaluation process is applicable not only to measuring the adaptive reuse potential of the entire industrial heritage park but also to determining the development timing of individual industrial architecture heritage and the relative sizes of their respective reuse potentials within a park. To increase the compatibility of the evaluation methods, the system of evaluation of reuse potential proposed in this paper includes the evaluation of the potential of renovated and reused industrial architecture heritage, determining the advantages and disadvantages of their potential and defining the possibility of future adjustment.

6. Conclusions

This paper takes as its research object the existing successfully reused industrial parks in Beijing, combines the current reuse statuses and potentiality characteristics of the urban dimension, breaks through the traditional emphasis on the value assessment of the heritage itself, introduces potential evaluation factors that promote urban renewal, and forms a multi-faceted and multi-level comprehensive reuse potentiality evaluation system. Through a comprehensive comparison of various evaluation methods and by taking into account the fuzzy nature of the indicators of the evaluation object of potential, linearly weighted comprehensive weights are used to determine the parameters of each indicator, and Improved Entropy TOPSIS is used to quantify the ranking and relative value of industrial park reuse potentiality. Finally, the scientific validity and feasibility of the research framework for revealing the reuse advantages and potential distribution of established industrial heritage sites are validated through the application of actual cases in industrial parks. The industrial heritage reuse potentiality evaluation study enhances the accuracy and effectiveness of proprietors and practitioners in formulating reuse strategies at the implementation level, thereby maximizing the sustainable use of scarce resources. The revitalization of industrial heritage through adaptive reuse continues historical lineage and contributes to urban development.

The assessment of the reuse potentiality of industrial heritage involves many evaluation index factors, and this paper only calculates the relative value of potentiality for the primary and secondary evaluation index systems because the scoring basis and index composition of the three-tier index system may change due to the different evaluations of industrial heritage parks. It is necessary to further quantify the potentiality of the evaluation content and score after a specific analysis of the evaluation objects. The focus of this paper is to propose the content of graded indicators and the calculation of the relative potential size for the evaluation of industrial heritage in utilization potentiality in the urban dimension with insufficient research on optimization and improvement after the evaluation. The next stage will be to scientifically analyze the potentiality distribution of each park based on the research findings, clarify the advantages and disadvantages of transformation, and then enhance the reuse potential evaluation index system.

The evaluation system contains more indicators to obtain more comprehensive evaluation data, and it is difficult to determine the evaluation parameters and obtain the corresponding data, so the scientific quantification of the indicator data and the simplification of the evaluation system are future directions for research improvement. To broaden the compatibility of the evaluation methods and adapt them to various phases of reuse, such as preliminary research, design, construction, and operation, it is necessary to strengthen and improve the potentiality evaluation system by supporting cross-disciplinary and actual research.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Standardized processing of user indicator evaluation data.

Evaluation Indicator System		Campus Case Measurement							
Primary Indicators	Secondary Indicator	Shougang Industrial Park		751D·PARK		No. 27 Factory 1897 Science and Technology Innovation City		Laijin Cultural and Creative Industrial Park	
		Weighted Data		Weighted Data		Weighted Data		Weighted Data	
Intrinsic Value (Building Dimension)	Landscape Integrity	0.0241	0.1106	0.0182	0.0884	0.0252	0.1013	0.0235	0.1054
	Structural Reliability	0.0326		0.0148		0.0138		0.0314	
	Heritage Authenticity	0.0276		0.0200		0.0278		0.0162	
	Safety	0.0263		0.0355		0.0345		0.0343	
Intrinsic Value (Regional Dimension)	Location	0.0080	0.0351	0.0135	0.1231	0.0105	0.1215	0.0248	0.1226
	Surrounding Environment	0.0032		0.0122		0.0233		0.0145	
	External Space	0.0000		0.0338		0.0336		0.0300	
	Planning Restrictions	0.0166		0.0240		0.0254		0.0273	
	Infrastructure	0.0072		0.0396		0.0286		0.0259	
Retrofit Value (Building Dimension)	Functional Variability	0.0238	0.0927	0.0221	0.0841	0.0156	0.0912	0.0252	0.0583
	Architectural Sustainability	0.0131		0.0163		0.0084		0.0201	
	User Attitude	0.0289		0.0209		0.0285		0.0051	
	Construction Technology Implementation	0.0269		0.0248		0.0386		0.0080	
Retrofit Value (Regional Dimension)	Expected Results	0.0393	0.1289	0.0328	0.1171	0.0372	0.0986	0.0029	0.1064
	Economic Conditions	0.0153		0.0203		0.0053		0.0164	
	Political Context	0.0358		0.0145		0.0144		0.0331	
	Participants' Attitudes	0.0148		0.0194		0.0151		0.0272	
	Legal Policies	0.0236		0.0300		0.0267		0.0269	
Potential Benefits (Building Dimension)	Humanistic Values	0.0267	0.1584	0.0286	0.0969	0.0267	0.1103	0.0248	0.0961
	Artistic Value	0.0224		0.0250		0.0108		0.0322	
	Expected Impact	0.0335		0.0319		0.0378		0.0308	
	Scientific and Technological Value	0.0382		0.0000		0.0350		0.0000	
	Representation and Scarcity	0.0376		0.0114		0.0000		0.0083	
Potential Benefits (Regional Dimension)	History Continuity	0.0280	0.1576	0.0242	0.1356	0.0119	0.1125	0.0049	0.0548
	Cultural Evaluation	0.0193		0.0354		0.0334		0.0183	
	Social Effects	0.0410		0.0350		0.0415		0.0209	
	Value-added Location	0.0335		0.0239		0.0093		0.0081	
	Future Earnings	0.0358		0.0171		0.0164		0.0025	

Table A2. Standardized processing of user indicator evaluation data.

Evaluation Indicator System		**Campus Case Measurement**							
Primary Indicators	**Secondary Indicator**	**Xinhua 1949 Cultural and Financial Industrial Park**		**768 Cultural and Creative Industrial Park**		**798 Art Park**		**Beijing Langyuan Cultural Creative Park**	
		Weighted Data		**Weighted Data**		**Weighted Data**		**Weighted Data**	
Intrinsic Value (Building Dimension)	Landscape Integrity	0.0230	0.0921	0.0172	0.0948	0.0210	0.1074	0.0153	0.0775
	Structural Reliability	0.0285		0.0311		0.0361		0.0175	
	Heritage Authenticity	0.0147		0.0200		0.0142		0.0113	
	Safety	0.0259		0.0266		0.0361		0.0334	
Intrinsic Value (Regional Dimension)	Location	0.0190	0.0790	0.0365	0.1149	0.0342	0.1172	0.0219	0.1070
	Surrounding Environment	0.0147		0.0234		0.0144		0.0212	
	External Space	0.0260		0.0149		0.0317		0.0335	
	Planning Restrictions	0.0143		0.0109		0.0177		0.0153	
	Infrastructure	0.0050		0.0212		0.0192		0.0152	
Retrofit Value (Building Dimension)	Functional Variability	0.0158	0.0730	0.0050	0.0478	0.0254	0.0996	0.0119	0.0303
	Architectural Sustainability	0.0158		0.0027		0.0164		0.0029	
	User Attitude	0.0172		0.0249		0.0367		0.0155	
	Construction Technology Implementation	0.0241		0.0152		0.0212		0.0000	
Retrofit Value (Regional Dimension)	Expected Results	0.0340	0.0944	0.0045	0.0455	0.0283	0.0715	0.0080	0.0360
	Economic Conditions	0.0178		0.0136		0.0000		0.0049	
	Political Context	0.0173		0.0158		0.0107		0.0000	
	Participants' Attitudes	0.0178		0.0010		0.0044		0.0115	
	Legal Policies	0.0075		0.0107		0.0281		0.0115	
Potential Benefits (Building Dimension)	Humanistic Values	0.0250	0.0514	0.0045	0.0571	0.0090	0.1189	0.0046	0.0835
	Artistic Value	0.0097		0.0136		0.0188		0.0195	
	Expected Impact	0.0066		0.0158		0.0370		0.0033	
	Scientific and Technological Value	0.0000		0.0010		0.0231		0.0162	
	Representation and Scarcity	0.0100		0.0107		0.0310		0.0400	
Potential Benefits (Regional Dimension)	History Continuity	0.0200	0.1180	0.0178	0.1399	0.0172	0.1284	0.0192	0.1009
	Cultural Evaluation	0.0354		0.0266		0.0343		0.0150	
	Social Effects	0.0364		0.0467		0.0286		0.0413	
	Value-added Location	0.0146		0.0239		0.0281		0.0142	
	Future Earnings	0.0115		0.0250		0.0202		0.0114	

Table A3. User TOPSIS evaluation calculation results.

Item	Positive Ideal Solution Distance D_i^+	Negative Ideal Solution Distance D_i^-	Relative Proximity C_i^*	Sort Results
Shougang Industrial Heritage Park	0.355	0.593	0.626	1
798 Art Park	0.352	0.525	0.599	2
751D·PARK	0.367	0.527	0.589	3
No. 27 Factory 1897 Science and Technology Innovation City	0.396	0.540	0.577	4
Laijin Cultural and Creative Industrial Heritage Park	0.499	0.479	0.49	5
Xinhua 1949 Cultural and Financial Industrial Heritage Park	0.482	0.398	0.452	6
768 Cultural and Creative Industrial Heritage Park	0.495	0.387	0.439	7
Beijing Langyuan Cultural Creative Park	0.549	0.369	0.402	8

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Two-Scaled Identification of Landscape Character Types and Areas: A Case Study of the Yunnan–Vietnam Railway (Yunnan Section), China

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Abstract: In recent decades, the role of heritage railways has gradually shifted from transportation, economy, and trade to tourism, culture, and ecology. The heritage railway landscape is experiencing multiple changes along with a value ambiguity problem. There is a need to comprehensively recognize this landscape in order to promote the transformations and monitor the changes. Inspired by Landscape Character Assessment (LCA), this paper adopts a two-scaled identification framework of landscape character types and areas of the Yunnan–Vietnam Railway (Yunnan section) by integrating holistic and parametric methods. At the regional scale, the landscape character was divided by five natural variables: landform, vegetation, hydrology, soil, and geology. At the corridor scale, the landscape character was classified by five natural and cultural variables: altitude, slope, aspect, land use, and heritage density. At these two scales, k-prototype cluster analysis and multiresolution segmentation (MRS) tool were used to identify landscape character types and areas. The results showed that there were 11 different landscape character types and 80 landscape character areas at the regional scale, and 12 different landscape character types and 58 landscape character areas at the corridor scale. Furthermore, the composition, area, and distribution of these landscape character types and areas were described. The results of this study can form a database for planning, management, and evaluation of the railway.

Keywords: Yunnan–Vietnam Railway (Yunnan section); two-scaled identification; landscape character

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1. Introduction

Heritage railways have played an important role in history from the first advent of steam trains in the world [1]. Today, most are in poor repair and unable to compete with road transport due to their inefficiency and slowness [2]. Through travel literature and other advertisements, people have begun to accept railways as a daily mode of transportation, and the appeal of such railways is growing. The heritage railway tourism industry has recently seen a resurgence of interest in travel by historic train [3,4]. Moreover, in many countries around the world, heritage railways are being converted into railway museums, greenways, or parks [5–7]. Tourism, culture, and ecological values are becoming increasingly important with respect to railways. Management and planning of heritage railways, however, is becoming too heritage-oriented to ignore the railway natural landscape, and there is incomplete understanding of the railway landscape. Landscape can be clearly explained when it is classified by spatial units, which is of great significance for recognition of its abundance and heterogeneity [8]. LCA combines natural and cultural landscapes with people's perceptions [9,10]; it is a method for recognizing the spatial units that provide a locality its "sense of place" and pinpointing the heterogeneity of adjacent areas [11,12]. Moreover, it can be carried out at many different scales, and provides a framework for the implementation of the European Landscape Convention (ELC) [13,14].

In recent years, landscape character research methods have proliferated. The existing research methods used in the study of landscape character are primarily divided into holistic and parametric methods. Holistic methods tend to be intuitive, descriptive, and expert-oriented [15], and exclude the quantitative indicators of visual perception proposed in recent studies [16]. Parametric methods, on the other hand, tend to overlay or combine maps of different topics into a new comprehensive map [17]. The growth of open digital resources and the advancement of statistical methods have greatly promoted the development of parametric methods. ArcGIS overlay analysis of thematic maps, statistical analysis, or a combination of these two analyses are universally utilized [18,19]. Although relatively objective, parametric methods are highly dependent on the selection of the data, and are limited by differences in data sources, time, resolution, and scale [20–22]. When using this approach, it is important to capture, sort, and combine the available data sources [23,24]. Using a single method to study landscape characteristics is not suitable for all locations, and the integration of multiple methods is an inevitable trend. Inspired by the idea of multi-scale classification for LCA, research frameworks that integrate holistic and parametric approaches are beginning to emerge [25]. Yang and Gao adopted a framework for classifying landscape character types and areas using two-step cluster analysis and the MRS tool [26]. However, this framework does not take into account the correlation of landscape character variables and the mixed attributes of data. In addition, despite its widespread use in rural areas and national parks, LCA has not yet been extended to railway research.

The main objective of this study is to provide a more efficient and flexible LCA framework that can recognize the landscape characteristics of railways. Our specific objectives are: (i) to describe two-scaled identification of landscape character types and areas for the railway by integrating holistic and parametric methods, which can provide a reference for other heritage railway or linear heritage research; and (ii) to identify the natural and cultural characteristics of a heritage railway at two scales in order to provide a basic database for future planning, management, and evaluation.

2. Materials and Methods

2.1. Study Area

The Yunnan–Vietnam Railway, connecting Haiphong (the largest port city in northern Vietnam) and Kunming (the capital city of Yunnan, China), has a long history of over 120 years. The railway traverses 854 km, of which the Vietnam section (from Haiphong to Laocai) is 389 km and the Yunnan section (from Hekou to Kunming) is 465 km [3]. The Yunnan–Vietnam Railway was the first international alpine narrow-gauge railway in China, and is an outstanding example of Asian alpine narrow-gauge railway technology at the turn of the 20th century. It played an important role in the transformation and economic development of Yunnan and Vietnam. Its name was inscribed on the first edition of the Chinese Industrial Heritage List in 2018 [4]. A rich and heterogeneous landscape, including undulating mountains, natural rivers, plateaus, valleys, and many historical sites, is distributed along the railway. This paper adopted a hierarchical classification framework, and the study area included two-scaled boundaries. At the regional scale, it was made up of 17 counties, districts, and county-level cities along or near the railway. At the corridor scale, it was determined as a 15.8 km-wide linear buffer along the railway, which covered 76.9% of the total resource points (Figure 1).

2.2. Selection of the Variables and Data Sources at Two Scales

At the regional scale (using 1 km × 1 km grid cells and 30 m spatial resolution), the landscape character was divided by five variables (landform, vegetation, hydrology, soil, and geology) to explore the natural features of the railway on a large scale. The five variables were graded into 45 landscape indicators, and the first letters of the variables were used as capitalized acronyms to represent these landscape indicators (Table 1). The correlation tests between the variables were conducted before clustering as the correlation could affect the clustering results [27]. Chi-squared and Lambda tests were used to determine the correlation of the five categorical variables, which were relatively independent for their low correlation. The Digital Elevation Model (DEM, ASTER GDEM 30M) was obtained from the Geospatial Data Cloud website (http://www.gscloud.cn/search, accessed on 21 May 2022). The hydrological data were calculated based on the DEM in ArcGIS. The soil and vegetation datasets were collected from the Institute of Soil Science, Chinese Academy of Sciences. The data on landforms (2016, 1:2,700,000) and geology (2014, 1:2,700,000) were obtained from the China Geological Survey website (https://www.cgs.gov.cn/, accessed on 5 June 2022).

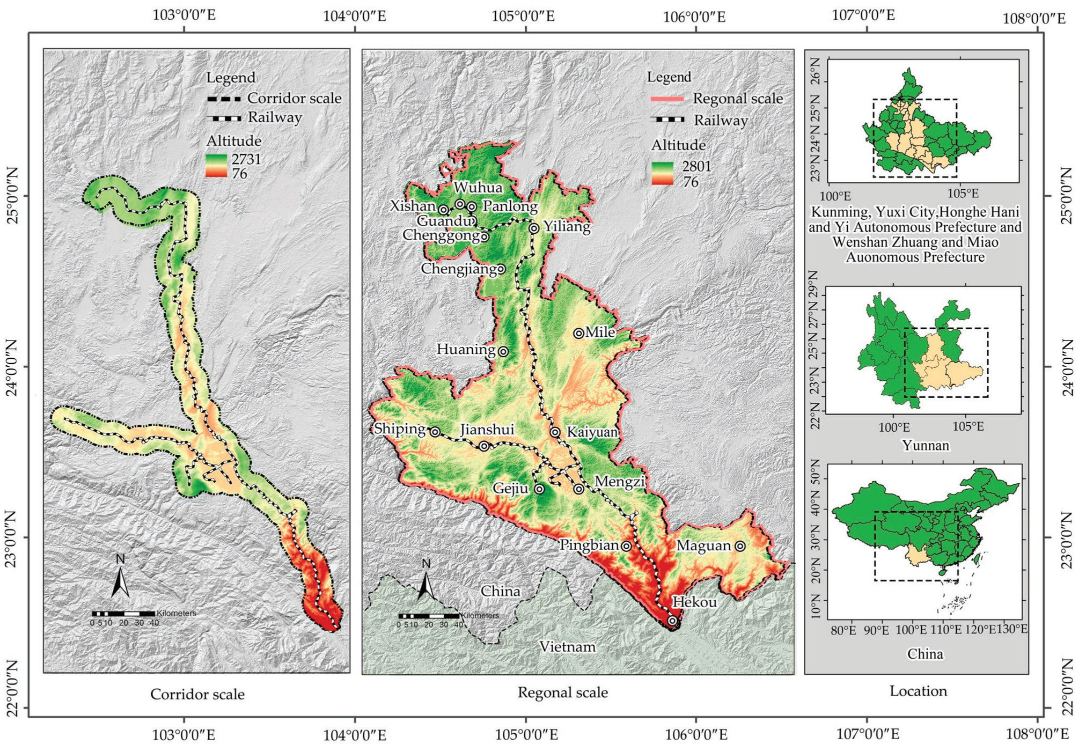

Figure 1. Location and two-scaled boundaries of the Yunnan–Vietnam Railway (Yunnan section).

At the corridor scale (using 0.5 km × 0.5 km grid cells and 12.5 m spatial resolution), we focused on the natural and cultural features of the railway and its surrounding environment. The landscape character was classified by six variables: altitude, relief, slope, aspect, land use, and heritage density. Pearson analysis was used to analyze the correlations of five continuous variables. The correlation coefficient between slope and relief was 0.974, showing high correlation. Considering its influence on railway landscape character, the relief variable was excluded. Finally, five variables were selected and divided into 24 indicators, which were coded with Greek alphabet characters such as α and β (Table 2). The DEM data (ALOS 12.5 M DEM) were obtained from the Alaska Satellite Facility website (ASF, https://search.asf.alaska.edu/, accessed on 3 June 2022). The datasets for slope and aspect were calculated based on the DEM. Sentinel-2 data (10 m resolution) from the United States Geological Survey website (USGS, https://earthexplorer.usgs.gov/, accessed on 2 June 2022) were used. The data on land use were calculated based on the Sentinel-2 data in ENVI. There were 300 heritage sites identified along the railway, involving industrial railway heritage, Chinese traditional villages, and various national scenic and historic areas. Heritage density was calculated using 1 km × 1 km grid cells.

Table 1. Variables used for landscape classification at the regional scale.

Variables and Landscape Indicators	Codes	Variables and Landscape Indicators	Codes
Landform		Red earths	S5
Plateau subregion	L1	Lateritic red earths	S6
Plateau basin subregion	L2	Torrid red earths	S7
Plateau lake basin subregion	L3	Latosols	S8
Karst middle mountain platform subregion	L4	Limestone soils	S9
Vegetation		Cinnamon soils	S10
Subtropical and tropical grasslands	V1	Paddy soils	S11
Broadleaf evergreen forests in subtropical zone	V2	Alluvial soils	S12
Broadleaf deciduous forests in subtropical zone	V3	Purplish soils	S13
Tropical rain forests	V4	Lake, marshes and urban	S14
Needleleaf forests in subtropical zone	V5	Geology	
Needleleaf forests in tropical zone	V6	Quaternary system	G1
Evergreen and deciduous scrubs in subtropical and tropical zone	V7	Neogene system	G2
Steppes	V8	Jurassic system	G3
Cultivated vegetation	V9	Triassic system	G4
Lake, marshes and urban	V10	Permian system	G5
Hydrology		Emeishan basalts	G6
River of 1 level	H1	Carboniferous-Permian system	G7
River of 2 level	H2	Devonian system	G8
River of 3 level	H3	Devonian-carboniferous system	G9
River of 4 level	H4	Silurian system	G10
River of 5 level	H5	Cambrian-Ordovician system	G11
River of 6 level	H6	Cambrian system	G12
Lake	H7	Paleozoic erathem	G13
Soil		Sinian system	G14
Brown earths	S1	Nanhua system	G15
Dark brown earths	S2	Mesoproterozoic erathem	G16
Yellow-brown earths	S3	Paleoproterozoic erathem	G17
Yellow earths	S4		

Table 2. Variables used for landscape classification at the corridor scale.

Variables and Landscape Indicators	Codes	Variables and Landscape Indicators	Codes
Altitude		135–225 (sunny slope)	γ4
≤500 m (low altitude)	α1	225–315 (semi-sunny slope)	γ5
500–1000 m (middle altitude)	α2	Land use	
1000–1500 m (middle-high altitude)	α3	Arable land	θ1
>1500 m (high altitude)	α4	Built area	θ2
Slope		Water	θ3
≤5° (flat slope)	β1	Forest land	θ4
5°–15° (gentle slope)	B2	Grassland	θ5
15°–25° (ramp slope)	B3	Unused land	θ6
25°–35° (steep slope)	β4	Heritage density (number of heritages per 1 km^2)	
>35° (abrupt slope)	β5	0–2 (low density)	ε1
Aspect		2–4 (middle density)	ε2
−1 (flat)	γ1	4–6 (middle-high density)	ε3
0–45, 315–360 (shady slope)	γ2	>6 (high density)	ε4
45–135 (semi-shady slope)	γ3		

2.3. Analysis Methods

This paper adopted a methodological framework combining the holistic and parametric approaches. The framework primarily included three-stage process: (a) selection of data sources; (b) recognition of landscape character types; and (c) division and description of landscape character areas (Figure 2).

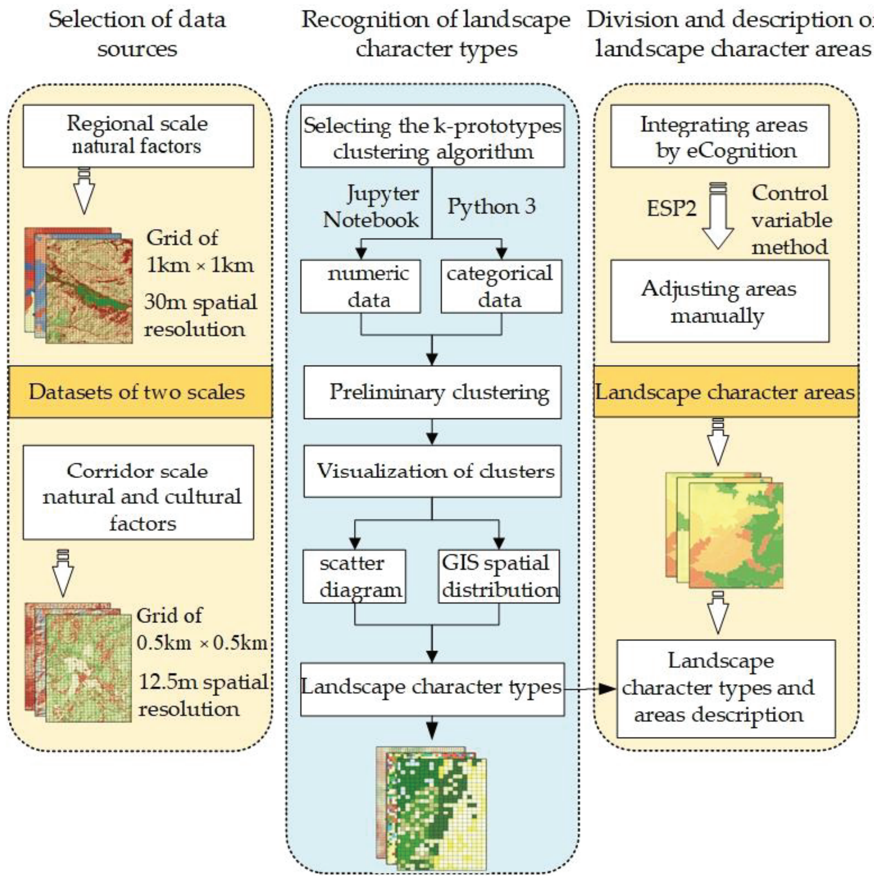

Figure 2. Methodological framework used to classify landscape character types and areas.

First, all the data variables were entered into ArcGIS in order to unify the coordinate system, spatial resolution, and grid cells at each scale. A 30 m spatial resolution and 1 km × 1 km grid cells were selected for the regional scale, while 12.5 m spatial resolution and 0.5 km × 0.5 km grid cells were selected for the corridor scale. All variables were divided into grid cells in order to establish a matrix that connected the variables and the grid cells through extracted multi-values to point and spatial join tools. In this way, it was ensured that each grid cell had unique corresponding landscape indicators. For example, one grid cell at the regional scale could consist of the indicators L3, V5, H7, S4, and G3. The connection matrix at the two scales was imported into SPSS25. Standardized processing and correlation analysis were performed to eliminate the influence of dimensionality and ensure the independence of the variables.

Second, the data matrix was imported into the Jupyter Notebook platform and the Python programming language was used to program the k-prototypes clustering algorithm. The landscape character types were classified by scatter plots and spatial distribution of clusters. The landscape character types were represented by landscape indicator codes; when a ratio of landscape indicator to landscape character type X accounted for more than 60%, it was indicated as "X", as "{X}" for a ratio between 30% and 60%, and as "(X)" for a ratio between 10% and 30%. When a ratio accounted for less than 10%, it was not represented. The purpose of clustering is to divide a set of data objects into multiple clusters in such a way that the data objects in one cluster are more similar than those in the other clusters [28,29]. The initial prototype of the k-prototypes algorithm was a k-means algorithm, which was primarily used to analyze numerical data. Then, the k-modes algorithm was extended to a k-means algorithm to deal with categorical data [30]. The k-prototypes algorithm integrates the k-means and k-modes algorithms, which can be applied to analyze numerical and categorical mixed data [31,32]. In this paper, we selected the k-prototypes clustering algorithm as a parameterized method for identifying landscape character types by fully considering the mixed attributes of landscape variables. The objective function is as follows [33]:

$$E = \sum_{i=1}^{n}\sum_{j=1}^{k} w_{ij} d\left(x_i, u_j\right) \tag{1}$$

where w_{il} is an element of the partition matrix, $W_{n\times k}$. $x_i(i = 1\ldots, n)$ are the objects in the dataset, $u_j(j = 1 \ldots k)$ are the prototype observations or the representative vectors for clusters, and $d(x_i, u_j)$ is the degree of dissimilarity, defined below:

$$d\left(x_i, u_j\right) = \sum_{m=1}^{q}\left(x_i^m - u_j^m\right) + \gamma \sum_{j=p+1}^{m} \delta\left(x_i^m, u_j^m\right) \tag{2}$$

where the first term is the squared Euclidean distance for the numerical variables and the second term is the simple matching dissimilarity for categorical attributes. Here, γ is the weight for categorical attributes, and the simple matching dissimilarity is

$$\delta(a, b) = \begin{cases} 0 & (a = b) \\ 1 & (a \neq b) \end{cases} \tag{3}$$

Finally, the landscape character areas were delimited by multiresolution segmentation (MRS) and manual delineation. MRS is a bottom-up region merging technique that is commonly used for the classification of objects; it has frequently been applied to image processing and classification [34]. The control variable method was used to set the MRS parameters. We first set the scale and compactness parameters to 100 and 0.5, then successively tested the segmentation effect of shape parameters from 0 to 0.9 to determine the best shape parameter a). Then, the scale parameter and shape parameter were set to 100 and a, respectively, and the segmentation effect of the compactness parameters of 0–1 were tested successively to establish the compactness parameter b. After the shape and compactness parameters were established, the scale parameter c was determined by estimating the peak value of the plug-in by estimating the scale parameter (ESP2). In this way, parameters a, b, and c of the segmentation were obtained. As the results were always over-segmented, manual delineation was used to adjust the results.

3. Results

3.1. Landscape Character Types and Areas at the Regional Scale

At the regional scale, five variables for 45 landscape indicators were divided into 30,591 grid cells. Eleven landscape character types were classified by the scatter plots and spatial distribution of clusters (Figure 3). Type 3 covered a maximum area of 4363 km^2, type 11 covered a minimum area of 549 km^2, and the other clusters covered more than 1000 km^2 (Figure 4a). The ratios of the landscape indicators to the landscape character types were expressed by coding as detailed in the materials and methods section. Figures 3 and 4b show that “L3L4, V1V5V8V10, S5, H7 G4” accounted for more than 60% and were prominent characteristics of the types; “{L3L4}, {V4V5V7V8}, {S5S14}, {G1G3G8G12G15G16}” accounted for 30–60% and were typical characteristics; and “(L2L3L4), (V1V3V6V8V7V10V11), (S4S5S6S7S8S11), (G1G4G5G7G9G11G13G14G15G16 G17)” accounted for 10–30% and were general characteristics. The ratios of the landscape indicators to the landscape character types indicated the common feature of the railway that landform was prominent in or features typical of a plateau lake basin subregion or karst middle mountain platform subregion. The vegetation included various types of needleleaf forests in the subtropical zone, as well as grasslands and steppes in both the subtropical and tropical zones. The hydrology was characterized by plateau lakes and natural rivers where the soil was dominated by red earths, while the geology included various typologies of the Triassic system, Cambrian system, Devonian system, Nanhua system, Mesoproterozoic system, Quaternary system, and Jurassic system.

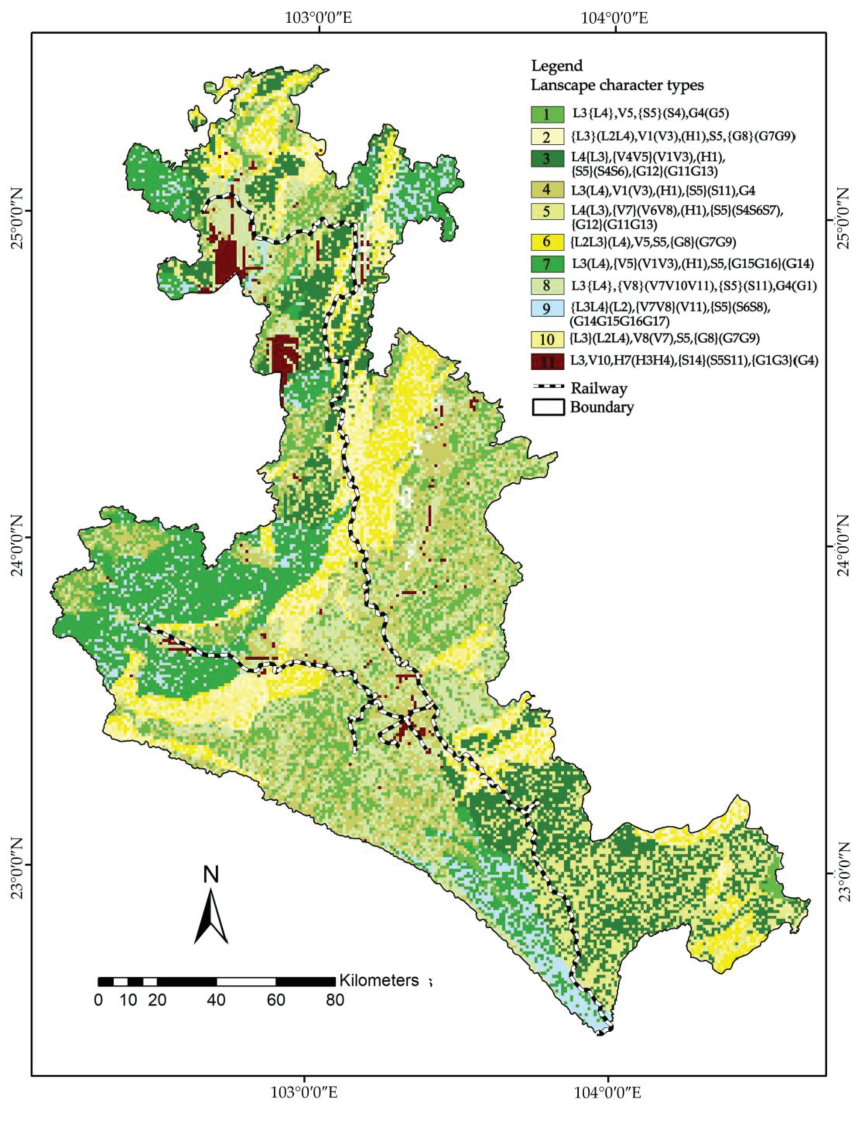

Figure 3. Landscape character types at the regional scale.

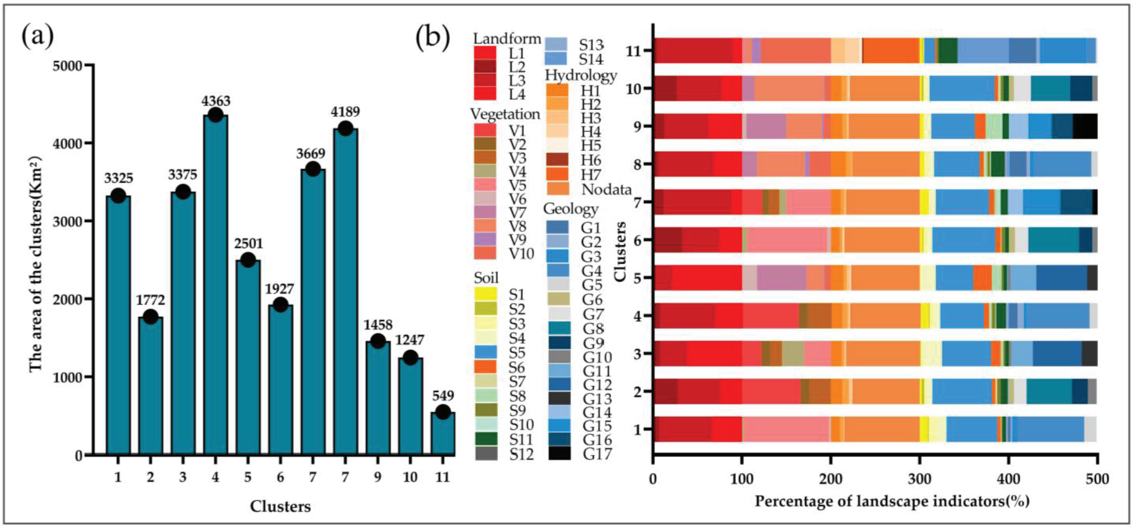

Figure 4. (**a**) Areas of landscape character types at the regional scale; (**b**) the ratios of landscape indicators to landscape character types at the regional scale.

The MRS tool was used to divide the landscape character areas. To ensure the segmentation effect, the scale, shape, and compactness parameters were set to 200, 0.4, and 0.1, respectively. A total of 98 landscape character areas were divided in eCognition (Figure 5A). Then, 80 landscape character areas were divided after manual adjustment (Figure 5B). The distribution of the landscape character areas in Kunming City and Yuxi City was relatively compact, while the distribution of the areas in Honghe Hani and Yi Autonomous Prefecture and Wenshan Zhuang and Miao Autonomous Prefecture was relatively sparse. The landscape character areas gradually decreased in number from north to south. The landscape character areas were more distributed when closer to an urban area and vice versa. In order to further identify the landscape character of the Yunnan–Vietnam Railway (Yunnan Section), 26 landscape character areas along the railway were selected to be named and described according to the prominent or typical features of the landscape character types and field survey (Appendix A) (Table 3). All of the 26 landscape character areas contained red earths, which was a highly representative landscape character along the railway. According to the landform statistics, seventeen landscape character areas contained plateau lake basin, three landscape character areas contained karst middle mountain platform, and six landscape character areas contained both plateau lake basin and karst middle mountain platform. According to the geology statistics, nine landscape character areas included the Triassic system, six landscape character areas included the Devonian system, three landscape character areas included the Cambrian system, and the others included mixed landscape indicators. In addition, there were several special areas. For instance, the landscape character areas for B5, B51, B54, and B71 were characterized as having urban and lake features, and B27, B73, B74, and B76 were characterized as having karst middle mountain platform and tropical rain forest, grassland, and shrub features.

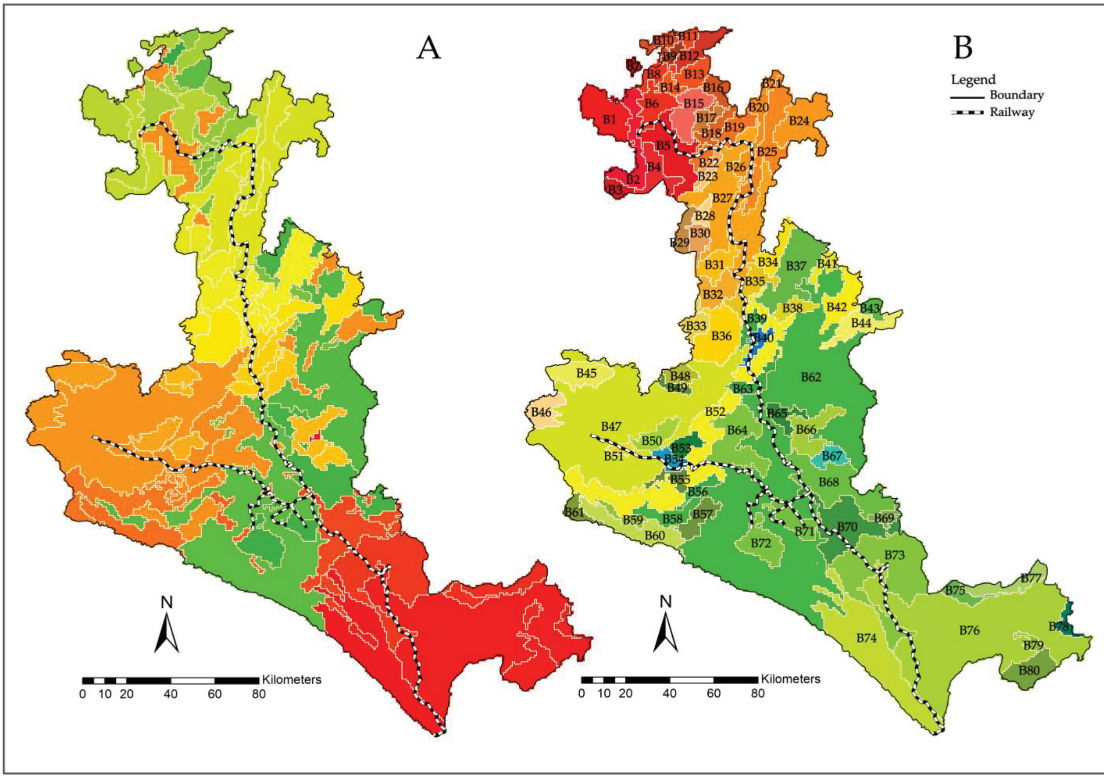

Figure 5. Landscape character areas at the regional scale: (**A**) delineation in eCognition; (**B**) delineation by manual adjustment.

Table 3. Descriptions of landscape character areas at the regional scale.

Areas	Types	Description	Areas	Types	Description
B5	8, 4, 9, 11	Urban and lake landscape in plateau lake basin subregion, with Triassic system, red earths, and grassland.	B39	2, 10	Steppes and grassland in plateau lake basin subregion, with Devonian system and red earths.
B6	8, 6, 2	Needleleaf forests and steppes landscape in plateau lake basin subregion, with Triassic system, Devonian system and red earths.	B40	6, 2	Needleleaf forests, grassland and steppes landscape in plateau lake basin and middle mountain platform subregion, with Devonian system and red earths.
B19 B32 B62 B64 B68 B72	4, 1, 8	Needleleaf forests, grassland and steppes landscape in plateau lake basin subregion, with Triassic system and red earths.	B51 B71	11, 4, 8	Yilong lake and Datunhai lake landscape in plateau lake basin subregion, with Triassic system, Jurassic system, quaternary system, red earths, grassland, and steppes.
B20	1, 9	Needleleaf forests landscape in plateau lake basin subregion, with Triassic system and red earths.	B52	2, 6, 10	Needleleaf forests, grassland, and steppes landscape in plateau lake basin subregion, with Devonian system and red earths.

Table 3. *Cont.*

Areas	Types	Description	Areas	Types	Description
B25 B35	6, 2, 10	Needleleaf forests and grassland landscape in plateau lake basin and middle mountain platform subregion, with Devonian system and red earths.	B54	7, 8, 4, 11	Urban, lake landscape and needleleaf forests in plateau lake basin subregion, with Nanhua system, Mesoproterozoic erathem, Triassic system and red earths.
B26	6, 2, 3	Needleleaf forests and grassland landscape in plateau lake basin and middle mountain platform subregion, with Cambrian system and red earths.	B63	4, 2, 6	Needleleaf forests and grassland landscape in plateau lake basin subregion, with Devonian system, Triassic system and red earths.
B27 B73 B76	3, 5	Tropical rain forest and shrubs landscape in middle mountain platform subregion, with Cambrian system and red earths.	B70	2, 6, 10, 7	Needleleaf forests, grassland, and steppes landscape in plateau lake basin subregion, with Devonian system and red earths.
B31 B47	7, 9	Needleleaf forests, shrubs and grassland landscape in plateau lake basin and middle mountain platform subregion, with Nanhua system, Mesoproterozoic erathem and red earths.	B74	7, 9, 8	Tropical rain forest and shrubs landscape in middle mountain platform and plateau lake basin subregion, with Nanhua system, mesoproterozoic erathem, Triassic system and red earths.

3.2. Landscape Character Types and Areas at the Corridor Scale

At the corridor scale, five variables of the 24 landscape indicators were divided into 35,554 grid cells. Combined with the scatter plots and the spatial distribution of clusters, 12 landscape character types were identified (Figure 6A). Type 6 covered a maximum area of 1224.4 km^2 and type 7 covered a minimum area of 17.75 km^2 (Figure 7a). Figures 6A and 7b showed that "α4, β1β2β3, γ4γ5, θ2θ4, ε1ε2" were the prominent landscape characteristics of the types, "{α3α4}, {β1β2β3β4}, {γ2γ3γ4γ5}, {θ1θ2}" were typical characteristics, and "(α2α3), (β1β2β3β4), (γ1γ2γ3γ4γ5), (θ1θ2θ3θ5), (ε3)" were the general characteristics (Figure 3). The ratios of the landscape indicators to the landscape character types showed a common feature of the railway, namely, that altitude was prominent in or typical of a middle-high altitude and a high altitude. The slope and aspect were diverse, encompassing flat slope, gentle slope, sunny slope, shady slope, etc. The land use included various types of arable land, built area, and forest land, while the heritage density was characterized by low and medium densities, with zero to four heritage points per square kilometer.

An effective segmentation was received when the parameters for scale, shape, and compactness were set to 100, 0.1, and 0.5, respectively. A total of 63 landscape character areas were divided in eCognition (Figure 6B). Then, 58 landscape character areas were divided after manual adjustment (Figure 6C). The landscape character areas were more distributed when they were closer to an urban area and vice versa. The landscape character areas were named and described by the landscape character types and the field survey (see Appendix B), as shown in Table 4. All of the 58 landscape character areas contained middle–high altitude and high altitude characteristics, which were highly representative landscape characters. Land use was the key variable for dividing the landscape character areas. The five areas containing water landscape characters were located in Dianchi, Fuxian, Yangzonghai, Yilong, and Datunhai Lake; 23 were characterized by forest land, 13 were characterized by arable land and built area types, and the others included mixed types of arable land, forest land, and built area. The landscape character areas for C6, C27, and C45 were characterized by medium- and low-heritage densities, which primarily covered the urban areas of Kunming City and the Kaiyuan and Mengzi County Cities.

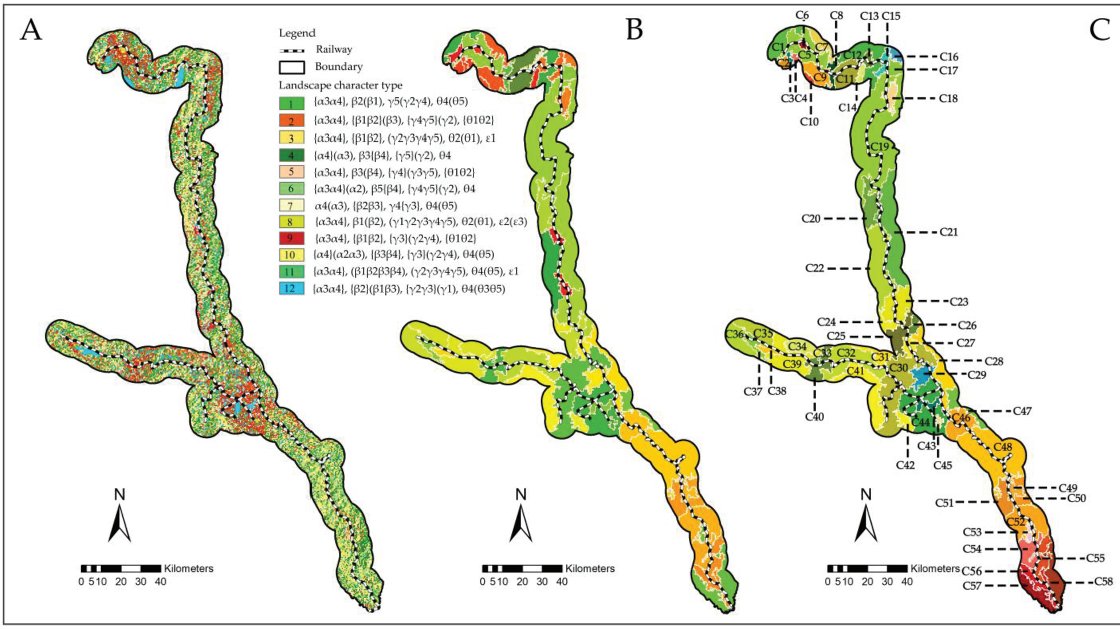

Figure 6. Landscape character types and areas at the corridor scale: (**A**) landscape character types; (**B**) delineation areas in eCognition; (**C**) delineation by manual adjustments.

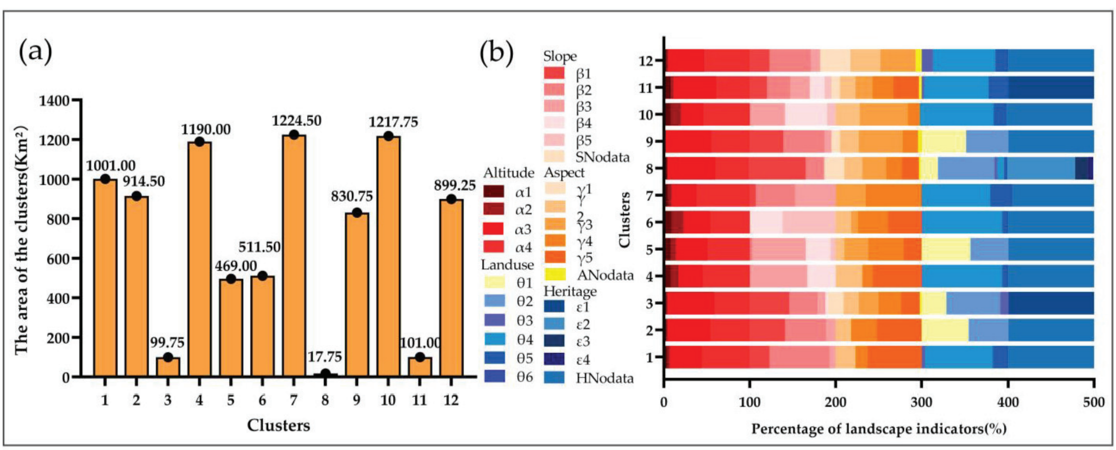

Figure 7. (**a**) Areas of landscape character types at the corridor scale; (**b**) the ratios of landscape indicators to landscape character types at the corridor scale.

Table 4. Descriptions of landscape character areas at the corridor scale.

Areas	Types	Descriptions
C1, C15, C42, C54	7, 10	Forest landscape in high altitude areas, with gentle slope, steep slope, ramp slope, sunny slope and semi-shady slope.
C2, C48, C52, C57	4, 10, 6	Forest landscape in middle-high and high-altitude areas, with ramp slope, steep slope abrupt slope, sunny slope, semi-sunny slope and semi-shady slope.
C3, C10, C14, C38, C43	12	Water landscape of Dianchi Lake, Fuxian Lake, Yangchuhai Lake, Yilong Lake, Datunhai Lake in middle-high and high-altitude areas, with gentle slope, shady slope and semi-shady slope.
C4	1, 2, 12	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with flat slope, gentle slope, sunny slope, shady slope, semi-sunny slope and semi-shady slope.
C5, C17, C18, C33, C37, C40, C44	2, 9	Arable, urban and rural landscape in middle-high and high-altitude areas, with flat slope, gentle slope, sunny slope, semi-sunny slope and semi-shady slope.
C6	3, 8	Urban heritage landscape in middle-high and high-altitude areas, with flat slope and gentle slope.
C7, C11	7, 1, 2	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with flat slope, gentle slope, ramp slope, semi-sunny slope and semi-shady slope.
C8	1, 2	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with flat slope, gentle slope, sunny slope and semi-sunny slope.
C9, C13	2, 9, 7	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with flat slope, gentle slope, ramp slope, sunny slope, semi-sunny slope and semi-shady slope.
C12, C19	10, 1, 4	Forest landscape in middle-high and high-altitude areas, with gentle slope, ramp slope, steep slope, semi-sunny slope and semi-shady slope.
C16, C47	2, 7	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with flat slope, gentle slope, ramp slope, sunny slope and semi-sunny slope.
C20, C39	10, 5, 4	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with ramp slope, steep slope, sunny slope, semi-sunny slope and semi-shady slope.
C21	7, 1, 4	Forest landscape in middle-high and high-altitude areas, with gentle slope, ramp slope, steep slope, semi-sunny slope and semi-shady slope.
C22, C30	7, 10, 2	Arable, urban and rural landscape in middle-high and high-altitude areas, with flat slope, gentle slope, ramp slope, steep slope, sunny slope, semi-sunny slope and semi-shady slope.
C23	10, 7, 1	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with flat slope, gentle slope, ramp slope, steep slope, sunny slope, semi-sunny slope and semi-shady slope.
C24	2, 9, 5	Arable, urban and rural landscape in middle-high and high-altitude areas, with flat slope, gentle slope, ramp slope, steep slope, sunny slope, semi-sunny slope and semi-shady slope.
C25, C34, C35, C41	10, 7, 4	Forest landscape in high-altitude areas, with gentle slope, ramp slope, steep slope, sunny slope, semi-sunny slope and semi-shady slope.
C26	2, 1, 4,	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with flat slope, gentle slope, ramp slope, steep slope, sunny slope and semi-sunny slope.
C27	2, 9, 3	Arable, urban and rural heritage landscape in middle-high and high-altitude areas, with flat slope, gentle slope, sunny slope, semi-sunny slope and semi-shady slope.
C28	7, 6, 4	Forest landscape in middle-high and high-altitude areas, with gentle slope, ramp slope, steep slope, abrupt slope, sunny slope, semi-sunny slope and semi-shady slope.
C29	2, 9, 12	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with flat slope, gentle slope, sunny slope, shady slope, semi-sunny slope and semi-shady slope.
C31	5, 2	Arable, urban and rural landscape in middle-high and high-altitude areas, with flat slope, gentle slope, sunny slope and semi-sunny slope.
C32, C46	7, 1, 12	Forest landscape in middle-high and high-altitude areas, with gentle slope, shady slope, semi-sunny slope and semi-shady slope.

Table 4. *Cont.*

Areas	Types	Descriptions
C36	10, 4, 2	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with flat slope, gentle slope, ramp slope, steep slope, sunny slope, semi-sunny slope and semi-shady slope.
C45	8, 2	Arable, urban and rural heritage landscape in middle-high and high-altitude areas, with flat slope, gentle slope, sunny slope and semi-sunny slope.
C49	4, 6	Arable, urban, rural and forest landscape in middle-high and high-altitude areas, with ramp slope, steep slope, sunny slope and semi-sunny slope.
C50	6, 7	Forest landscape in middle-high and high-altitude areas, with gentle slope, ramp slope, abrupt slope, sunny slope, semi-sunny slope and semi-shady slope.
C51	10, 6	Forest landscape in middle-high and high-altitude areas, with ramp slope, steep slope, abrupt slope, sunny slope, semi-sunny slope and semi-shady slope.
C53	5	Arable, urban and rural landscape in middle-high and high-altitude areas, with ramp slope and sunny slope.
C55	4	Forest landscape in middle-high and high-altitude areas, with ramp slope, steep slope, shady slope and semi-sunny slope.
C56	10	Forest landscape in high-altitude areas, with ramp slope, steep slope and semi-sunny slope.
C58	10, 7, 6	Forest landscape in middle-high and high-altitude areas, with gentle slope, ramp slope, steep slope, abrupt slope, sunny slope, semi-sunny slope and semi-shady slope.

4. Discussion

The landscape variables or indicators represent the spatial patterns of the entire landscape mosaic [35]. The classification of the landscape character of the variables (or indicators) by the clustering method can clearly explain the landscape, which is conducive to capturing its abundance and uniqueness [7]. At present, progress has been made in multi-scale research on landscape character. There are large-scale studies using national, regional, and local scales or large, medium, and small scales, regardless of the administrative scales, as well as studies using the region, corridor, and settlement scales [26,36,37]. On the basis of previous studies, in this paper we selected a combination of holistic and parametric methods to divide the two-scaled landscape character of the Yunnan–Vietnam Railway (Yunnan section) by considering the correlations, dimensional differences, and data mixture attributes of the landscape variables.

Our results showed that there 11 landscape character types and 80 landscape character areas at the regional scale and 12 landscape character types and 58 landscape character areas at the corridor scale. Landscape character types and areas were quite diverse in the different areas and scales for the different data sources, clustering methods, and identification modes [38]. For instance, Chongming Island in Shanghai was divided into 6 landscape character types, 18 landscape character sub-types, and 87 landscape character areas [39], while there were 17 landscape character types and 192 landscape character areas in Wuyishan National Park [40].

The landscape character types of the heritage railway were dominated by "L3L4, V1V5V8V10, S5, H7 G4L3, V5, G4" and typical in "{L3L4}, {V4V5V7V8}, {S5S14}, {G1G3G8G12G15G16}" at the regional scale, and were dominated by "α4, β1β2β3, γ4γ5, θ2θ4, ε1ε2" and typical in "{α3α4}, {β1β2β3β4}, {γ2γ3γ4γ5}, {θ1θ2}"at corridor scale. We took the prominent and typical characteristics as the basis for the division and description of landscape character areas, which is similar to previous research [41,42]. The main difference was that we analyzed the general characteristics. In addition, the ratios of the landscape indicators to the variables were closely related to the landscape character types. The higher the ratios, the more likely they were to be prominent or typical landscape types. The ratio of the red earths indicator to the soil variable was 55% at the regional scale and that of the forest land indicator to the land use variable was 58% at the corridor scale, both of which were prominent or typical features in the landscape character types at each scale. This was confirmed by the results of

Li's study on the landscape character of traditional settlements in the Wuling Mountain area at the regional scale [37]. Thus, landscape character types can be used to represent the ratios of the landscape indicators to the variables, which is of great importance for studying the spatial mosaic patterns of linear heritage landscapes and the data mining of resource features.

The spatial distribution of landscape character areas indicated that the landscape character areas were more distributed when closer to an urban area and vice versa. At the regional scale, the distribution of the landscape character areas in Kunming City and Yuxi City was relatively compact, while the distribution of the areas in Honghe Hani and Yi Autonomous Prefecture and Wenshan Zhuang and Miao Autonomous Prefecture was relatively sparse. The landscape character areas gradually decreased in number from north to south. At the corridor scale, the distribution of the landscape character areas in Kunming City, Jianshui County, Mengzi City, Kaiyuan County of Honghe Hani, and Yi Autonomous Prefecture was relatively compact, while the distribution in other areas was sparse. This was mainly because the areas were divided according to landscape character types and field survey. Urban areas contained more landscape types and more diverse combinations. For example, in urban areas there were landscape character areas characterized by water areas, arable land, and built areas, while the natural areas were dominated by forest land at the corridor scale. In addition, the concentration of the heritage railway was primarily in urban areas, which could also be divided into landscape character areas with medium- and low-heritage densities. The distribution of industrial heritage in natural areas was relatively sparse, making it difficult to form a heritage agglomeration area. The spatial distribution features of the landscape character areas could provide basic references for railway revitalization in each administrative region.

The two-scaled identification of landscape character provides a baseline for redefining the complex boundaries of the Yunnan–Vietnam Railway (Yunnan Section) and a framework for better management, planning, and judgement with respect to the landscape. The main limitations of this paper are two-fold: on the one hand, we adopted a top-down method for identifying the landscape character, ignoring public perceptions [43–45]; on the other hand, our study did not address landscape decisions. In future research, more detailed hierarchical identification involving public perceptions and landscape decisions should be realized.

5. Conclusions

This paper adopted a two-scaled identification framework of landscape character types and areas along the Yunnan–Vietnam Railway (Yunnan section) by integrating holistic and parametric methods. This framework was able to effectively identify the natural and cultural characteristics of the railway. Due to the flexibility of the method and data sources, it can be applied to other heritage railways or similar linear heritage sites. We identified 11 landscape character types and 80 landscape character areas at the regional scale and 12 landscape character types and 58 landscape character areas at the corridor scale. The identified landscape character types and areas can help in explaining those characteristics that provide a locality with its 'sense of place' and pinpointing the heterogeneity of adjacent areas, which is of great significance for landscape management, planning, and evaluation. The indicator composition, area, and distribution of these landscape character types and areas were described. The ratios of the landscape indicators to the variables were closely related to the landscape character types. The higher the ratios, the more likely they were to be prominent or typical landscape types. The spatial distribution of the landscape character areas indicated that they were more distributed when closer to an urban area and vice versa. These analysis results can help planners, managers, and stakeholders to scientifically understand the overall and individual characteristics of the types and distribution rules of areas.

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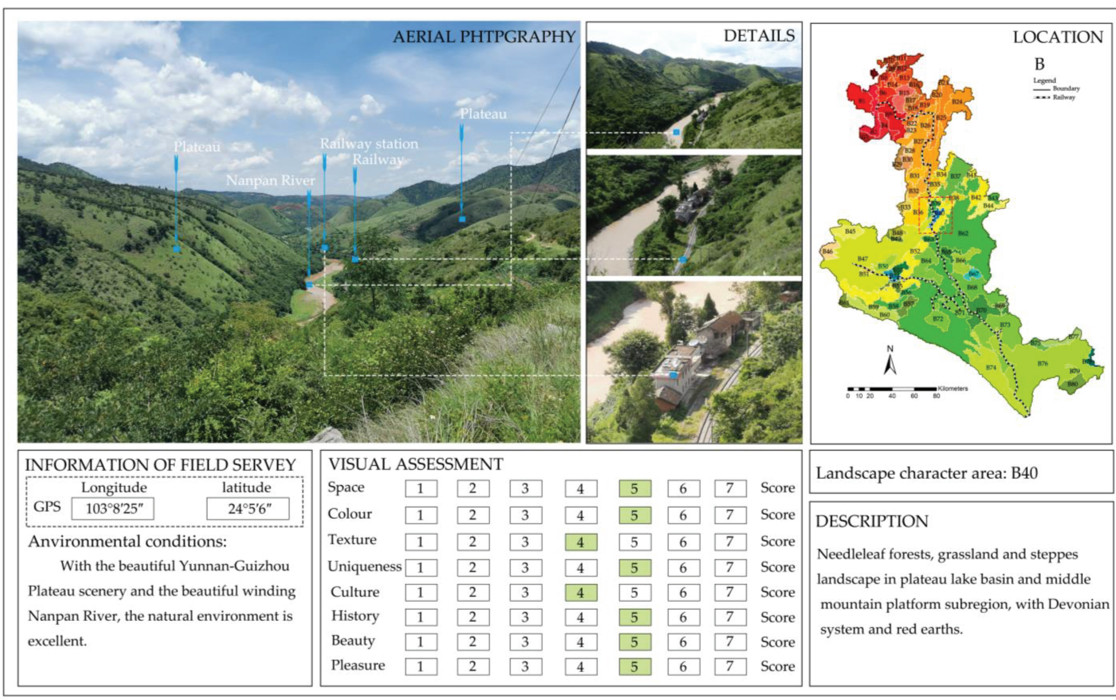
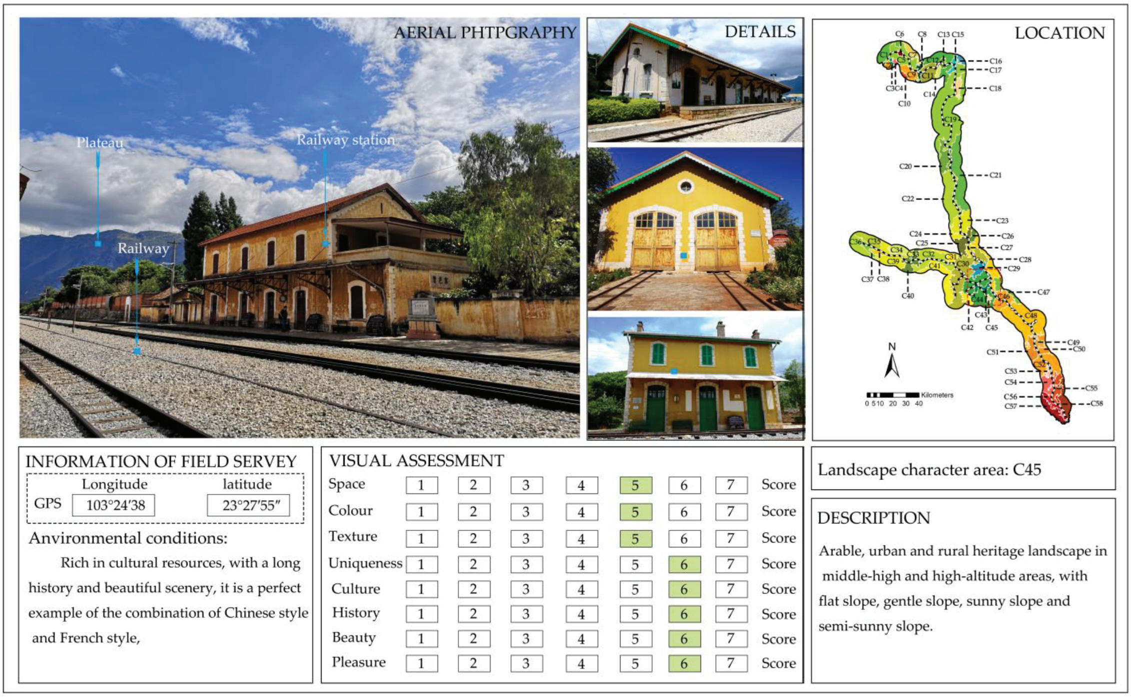
Appendix A. Field Survey Sheet at the Regional Scale



Appendix B. Field Survey Sheet at the Corridor Scale



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Article

Preference Model in the Context of Mobility as a Service: A Pilot Case Study

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Abstract: In this paper, a pilot study of a pre-test preference model in the context of mobility as a service (MaaS) is defined by following the steps required for transport system engineering: survey, specification, calibration, and validation. The availability of a MaaS preference model is crucial to support decision takers and decision makers before starting planning activities for new, sustainable transport services. In this paper, a pre-test model is proposed for evaluating user preferences. The pre-test model was specified with a Logit random utility model and the parameters were estimated using the maximum likelihood method. To define the preference model, a pilot survey was conducted in the Gioia Tauro area, an extra-urban area in southern Italy. For the pre-test model, a pilot sample of users was considered. In the area, a high percentage of users traveled by an individual transport system; this high percentage was also present in the survey, with 76% traveling by private car. Short- and long-distance scenarios were proposed to users. In the calibrated model, it emerged that bundles were more attractive for long-distance journeys and decreased with the cost of the package. The additional cost in the present scenario influenced the preference for bundle cost. Considering the parking cost in the present scenario (scenario 2), the MaaS preference probability started at higher probability values but increased less quickly. The pre-test model was defined starting from a pilot sample and represents the basis for a larger MaaS preference model built starting from a larger survey and a sample with a greater number of calibrated parameters.

Keywords: mobility as a service; reviled preference; survey; calibration

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1. Introduction

In this paper, a preference model for mobility as a service (MaaS) is reported. The proposed model can support decision makers and decisions takers in designing a complete survey and model for feasibility studies for planning sustainable transport systems. The specifications of the proposed pre-test model and the preliminary results can be used as a basis for the development of experimentation on a larger scale. The pre-test model is tested with a pilot survey in an area with weak transport demand.

MaaS is important because it allows the use of different modes and services of transport for traveling with adaptive travel demand and the use of a single digital interface. A state-of-the-art example is reported in [1]. A MaaS system has an integrated mobility service and an integrated digital platform for both users and operators (with users at the center of the system). In a transport system, fares and schedule integration, the sharing of a vehicle, information provided to users, and the existence of only joint services are not sufficient to be defined as a MaaS system [2].

In [2], the evolution of a MaaS system is proposed, from an N-MaaS (no transport service integration) to an S-MaaS (sustainable MaaS) composed of the following: transport integration and the availability of an information and communication technology platform

(I-MaaS); a transport decision support system platform (T-MaaS); and sustainability goals, such as those of Agenda 2030 (S-MaaS).

An analysis of the MaaS concept and a state-of-the-art example are reported in Section 2 with a table that contains the main characteristics of the papers analyzed. Some of the papers give a definition of MaaS. Other papers report examples of MaaS experiences in urban contexts, some of them with model calibration. The MaaS literature relative to the calibrated models (Section 2.2) focuses on urban areas; in this paper, a MaaS preference model in an extra-urban area is considered. In this paper, a pre-test model is presented for evaluating user preferences and for testing the feasibility of a MaaS system in an extra-urban context with weak transport demand.

The main objective of the paper is to propose a methodology for immediate application to be implemented with a low budget. The proposed model aims to provide the first indications in a preliminary evaluation step to decision makers and decision takers before starting planning activities. The proposed model hypothesizes two alternatives relating to the preference of users towards MaaS. The construction of the MaaS preference pre-test model is carried out with the following steps: survey, specification, calibration, and validation. The study can be considered as a pilot study and the results need to be confirmed with a larger survey and a more general model. To evaluate the pre-test model presented, a pilot application was developed in the Gioia Tauro area, an extra-urban area in southern Italy. Pilot data were collected in relation to road transport, rail, car sharing, bike sharing, and on-demand services.

This paper is divided into five sections. After Section 1, Section 2 describes the literature review. Section 3 describes the methods used for the specification, calibration, and validation of the pre-test model. To evaluate the applicability of the reported method, the preliminary results and discussion of the adopted pilot survey are reported in Section 4. Section 5 reports the main conclusions.

The main innovation reported in this paper is related to a MaaS preference pre-test model (Section 3) that can be adopted for the estimation of user preference with an immediate response and low budget before a more extensive survey and the more detailed specification, calibration, and validation of choice models. In order to test the applicability of the reported model, a pilot survey and experimentation in an extra-urban area with weak transport demand are reported (Section 4).

2. Literature Review

MaaS has been studied recently and there are numerous published scientific papers. With specific reference to MaaS, this section is divided in two subsections: the first concerns general aspects with particular reference to transport system models, and the second relates to surveys that have been carried out and calibrated models. Section 2.1 contains papers relative to general aspects concerning MaaS, while Section 2.2 focuses on the topic considered in the paper and is relative to the specification, calibration, and validation of demand models relative to MaaS.

2.1. MaaS and Transport System Models

In relation to general aspects, MaaS has recently been defined and investigated. It can be developed in a short time, and it is expected to be increasingly relevant in the future [2]. The first to introduce MaaS was Hietanen [3]. MaaS is the result of a union between transport systems and ICT technologies. In the context of MaaS systems, one of the major problems is due to the need to model user behavior and the consequences of decision makers' actions [4]. In this section, the state of the art is divided in relation to MaaS into the following: its definition and comparison; packages; experiences; supply models; and demand models.

In relation to MaaS definitions and comparisons, the scientific literature on MaaS is expanding and many different MaaS systems have been activated around the world.

- In [5], the MaaS literature (90 scientific publications and 21 MaaS-like schemes) was analyzed to define common elements across its definitions. It emerged that all MaaS systems are based on the use of a single app which allows users to carry out a series of operations, such as organizing a trip, payment, and access to mobility services, through a single channel. It provides information in real time, adapting to changes that services may undergo during the day [5].
- In [6], the literature (127 scientific publications) relative to the topic of MaaS was analyzed. The topic was found to occur consistently from 2018 [6]. Almost all the publications analyzed in the paper [6] were relative to Europe and were often based on research conducted in Sweden and Finland. In the paper, the results were classified according to market, users, data, and technology, as well as to how the world of transport is being transformed. In 39 of the 127 articles analyzed in the paper [6], users were subjected to surveys of their behavior. Age also influenced the attractiveness of MaaS [6], as confirmed in this paper.

In relation to packages, MaaS includes them for different transport modes with different payment methods [5–7]. In [7], the MaaS literature for defining the common elements that characterize a system, such as the integration of transport modes, fare options (bundle or "pay-as-you-go"), digital platforms, multiple actors, the use of technologies, demand orientation, registration requirement, personalization, and customization (the common elements were obtained from a table reported in [7]) were considered. In [1], the state of the art for an electric MaaS system was analyzed: starting from a MaaS system, they proposed an eMaaS system. In [8], the concept of MaaS, as well as the effects of MaaS for territories and citizens considering "environment, health and well-being, and social inclusion", and the consequences on urban governance were analyzed.

In relation to MaaS experiences, these services have been activated in some areas of Europe (i.e., a feasibility study for a MaaS system in London was developed [9]), while pilot projects have been launched in others. In Italy, a national research project for the study of MaaS was launched, a guideline for the development of MaaS in Italy was proposed, and two proposals have been published under the name of "MaaS for Italy" for pilot MaaS systems in metropolitan cities. Three pilot projects are currently supported through the first proposal in the cities of Milan, Naples, and Rome [2], with second proposals supported in Bari, Florence, and Turin.

In relation to transport supply models, MaaS consists of different components, such as institutional, management, immaterial, and material [9]. MaaS supply barriers relate to public–private cooperation, cybersecurity, business support, and coverage of public transport infrastructure [10,11]. In [9], an overview of transport operators in the city of London (such as fares offered, local coverage, and app availability) was considered.

In relation to transport demand models, some models have been analyzed and classified according to different characteristics: bundling according to modal choice, route choice, or both; RP (revealed preference) or SP (stated preference) surveys; or behavioral models or statistical analyses. In research papers, models can be calibrated [12] and the study area can range from a city to an entire country [12]. In [9], travel demand in London with data obtained from the London Travel Demand Survey and an SP-type survey was analyzed. In [13], a carpooling system to allow a reduction in demand during peak hours was studied, and in [14], movements from point A to point B starting from an itinerary with public transport and replacing some links of the network with carpooling (not dealing with the topic of MaaS) were considered. More details regarding the survey and calibration of demand models are given in Section 2.2.

2.2. MaaS Surveys and Model Calibrations

Transport demand models need to be specified, calibrated, and validated with surveys. Table 1 shows some main elements relative to some papers related to surveying and calibrating transport models in a MaaS context.

Table 1. Comparison between papers relative to MaaS surveys and model calibration.

Reference	MaaS Definition	Travel Choice	Survey *	Calibrated Parameters	Study Area
[15]		Mode	SP		The Netherlands
[16]	X		SP	X	Padua (Italy)
[17]		Bundle	RP/SP		Stretto di Messina (Messina Strait, Italy)
[18]		Mode	SP/RP		Stretto di Messina (Messina Strait, Italy)
[19]		Bundle/mode	SP	X	The Netherlands
[20]		Bundle	RP/SP	X	London (UK)
[21]		Bundle	RP/SP	X	London (UK)
[22]		Bundle	RP/SP	X	London (UK)
[23]			RP/SP		Reggio Calabria, Messina (Messina Strait, Italy)
[24]		Bundle			
[25]		Bundle/mode	SP/RP	X	Australia
[26]	X		SP		28 countries
[27]			SP		Edinburgh, Ticino, Brussels, Torino, Zagreb
[28]	X		SP		Canton Ticino, Brussels, Zagreb, and Ljubljana
[29]		Mode-service	RP/SP	X	Cambridge (USA)

* RP: revealed preferences; SP: stated preferences.

In Table 1, the main characteristics considered relevant for the study reported in this paper are as follows: the MaaS definition column refers to the definition of MaaS; the travel choice column refers to the specification of models relative to the choice of transport mode (i.e., individual vs. MaaS) or the choice of bundling within MaaS (i.e., different prices and services for MaaS); the survey column refers to the survey sample which can be relative to either RP or SP surveys; the calibrated parameters column refers to the calibration of the parameters of the demand models specified; and the study area column refers to the study areas considered in the papers.

Most of the papers reported in Table 1 concerned the probability of choosing a bundle. The type of survey was almost always of the SP type regarding calibration of the parameters of the demand models. In 6 out of 15 papers in Table 1 the parameters were calibrated. Most of the papers analyzed considered the following study areas: the Netherlands, London (UK), and the Strait of Messina.

In [15], the propensity for MaaS in the Netherlands was studied through an SP survey. Additionally, in [19] the same type of survey was conducted in the same study area, but in this case, the choice of travel was the bundle. While ref. [16] used the same type of survey, it was conducted in the city of Padua by interviewing municipal employees. In [18], adaptive user behavior in MaaS contexts was considered through SP and RP surveys. In [20,21], the same survey was used to estimate the models (London Mobility Survey); the area studied in both papers was London. In [22], the researchers analyzed the opportunities and barriers to the use of multimodal transport and how MaaS could support its use [22]. In [17], MaaS systems were not explicitly considered; instead, a preference model for the Messina Strait in southern Italy was considered, where there was discontinuity due to the Messina Strait. In the same area, ref. [23] analyzed the willingness to accept MaaS through an SP survey. In [25], a survey in Australia was conducted on a sample of 3985 people [25]. Other authors have not built preference models for MaaS, such as those of [24,26,27]. In [24], a literature review was included and a MaaS bundle design was proposed [24], and in [26], the figure of the mobility intermediary was studied. In [27], willingness to accept "SocialCar" and "new multi.modal mobility service" was studied through an SP survey conducted in five European cities, as reported in Table 1. In [28], intermodal travel consisting of carpooling and public transport to implement a MaaS system in suburban areas was considered. In [29], a demand model starting from data retrieved from smartphones was proposed.

Most of the MaaS literature has focused on urban areas; in this paper, a MaaS preference model in an extra-urban environment with weak demand is reported in the following sections.

3. Methods

The pre-test model proposed in this paper is relative to the preference of MaaS over traditional modes of transport. It can support decision makers and decision takers before the planning and designing of a sustainable MaaS system with more detailed models. For the definition of the model, the adopted method involved the following steps: specification (Section 3.1), calibration from a survey (Section 3.2), and validation (Section 3.3).

3.1. Specification

It is assumed that every user n (n is not reported for simplicity) has 2 alternatives available in choice set **I**:

$$\mathbf{I} = \{\text{yes, no}\} \tag{1}$$

where yes and no refer to the alternative of preferring or not preferring the MaaS scenario in a hypothetical context (stated preference).

Given choice set **I**, the choice of the alternative can be modeled through different models belonging to discrete choice theory, i.e., a random utility model (RUM), a fuzzy UM (FUM), or a quantum UM (QUM). Each user perceives a utility for each alternative belonging to **I** (U_{yes} or U_{no}) and prefers the alternative with the maximum perceived utility. With the reported assumption, the choice probability for the alternatives belonging to I is given by the following:

$$\begin{gathered} p(\text{yes} \mid \mathbf{I}) = probability(U_{yes} \geq U_{no}, \text{yes} \in \mathbf{I}, \text{no} \in \mathbf{I}) \\ p(\text{no} \mid \mathbf{I}) = 1 - p(\text{yes} \mid \mathbf{I}) \end{gathered} \tag{2}$$

In this paper, a RUM is adopted in the Logit family (assumed identical and independent Gumbel probability distribution with parameter θ for the perceived utilities associated to the 2 alternatives). The preference probabilities for the 2 alternatives are as follows:

$$\begin{gathered} p(\text{yes} \mid \mathbf{I}) = e^{Vyes/\theta} / (e^{Vyes/\theta} + e^{Vno/\theta}) \\ p(\text{no} \mid \mathbf{I}) = 1 - p(\text{yes} \mid \mathbf{I}) \end{gathered} \tag{3}$$

where

- V_{yes} is the expected value of utility for the alternative of yes.
- V_{no} is the expected value of utility for the alternative of no.

The ratio between the expected value of utility (V_k with k equal to yes or no) and the Gumbel parameter (θ) are commonly assumed as a linear combination of attributes (X_{1k}, X_{2k}, … reported in the vector of attributes $\boldsymbol{X}_k$), with parameters (β_1, β_2, … , reported in the vector of parameters $\boldsymbol{\beta}$) to be calibrated again during observation:

$$V_k/\theta = \beta_1 \bullet X_1 + \beta_2 \bullet X_2 + \ldots. = \boldsymbol{\beta}' \bullet \boldsymbol{X}_k \qquad \forall\, k \in \mathbf{I} \tag{4}$$

The choice probability for alternative k depends on the vector of the parameters to be calibrated and can be reported as a function $\rho()$ of alternative k subject to **I** and dependent on the vector of parameters $\boldsymbol{\beta}$ to be calibrated:

$$p(k \mid \mathbf{I}) = \rho(k \mid \mathbf{I}; \boldsymbol{\beta}) \qquad \forall\, k \in \mathbf{I} \tag{5}$$

3.2. Calibration

The utilities V_{yes}/θ and V_{no}/θ are specified in terms of attributes and parameters that require calibration from the observed data.

The calibration of the parameters can be carried out through surveys of single users (disaggregated data) or through user flows (aggregated data). The models adopted referring to individual users require the calibration of the vector of parameters with disaggregated RP and SP data and the maximum likelihood approach. Assuming independent observation n, the vector of the calibrated parameters ($\boldsymbol{\beta}$*) is obtained by the following:

$$\boldsymbol{\beta}^* = Arg\ max_{\boldsymbol{\beta}}\ L(\boldsymbol{\beta}) \tag{6}$$

where

$L(\boldsymbol{\beta}) = \prod_{n=1..N} \rho(k_n \mid \mathbf{I};\boldsymbol{\beta})$ is the likelihood function.
n is the generic user observed (or interviewed).
N is the number of users observed.
k_n is the alternative chosen by user n.

RP consists of the construction of a survey on behaviors revealed or demonstrated in real contexts; SP consists instead of the construction of a survey on behaviors declared by users in hypothetical contexts [30]. A pilot survey conducted on a small sample allows the definition of the size of an effective sample to conduct a full survey, and the results obtained in the study area are reported in Section 4.

3.3. Validation

Informal and formal tests can be considered for model validation.

Among the informal tests, the signs of the calibrated coefficients and their relationships can be verified, i.e., the value of time (VOT) or the ratio between the coefficient relating to time and that relating to monetary cost, which must be consistent with how much users are willing to pay [30]. In a transport alternative, a parameter characterized by a positive sign indicates that a user perceives positive utility in the choice relative to the corresponding attribute (i.e., comfort, quality of service or vehicles, and integration), while a parameter characterized by a negative sign indicates that a user perceives disutility (i.e., travel time or monetary cost). In the case of a model of MaaS preference, the sign of the parameter for distance (or a proxy variable) for a MaaS utility alternative may be positive because MaaS attractiveness can increase with distance.

Among the formal tests, there is that of Student's *t*-test of single coefficients, which verifies that the estimated parameters are equal to 0. This test establishes that a parameter estimate is significantly non-zero if the statistical test is not accepted [30]. This test is helpful in the calibration phase for evaluating if an attribute needs to be tested in different specifications; a high value of a constant indicates that there are other attributes of attractiveness or costs to be considered. The statistic for each parameter h is evaluated by the following:

$$t_h = \beta_h^* / \sigma(\beta_h^*) \tag{7}$$

where
β_h^* is the parameter h estimate using the maximum likelihood method and $\sigma(\beta_h^*)$ is the standard deviation relative to β_h^*.

Another formal test is the goodness of fit of a model ρ^2. This depends on the likelihood function evaluated with the vectors of calibrated parameters with optimal and 0 values. The values are in the range of [0; 1] in relation to the model reproduction of the choices of the sample [30]:

$$\rho^2 = 1 - ln(L(\boldsymbol{\beta}^*))/ln(L(\boldsymbol{\beta}^0)) \tag{8}$$

where
L is the likelihood function; $\boldsymbol{\beta}^*$ is the vector of the optimal values of the calibrated parameters; and $\boldsymbol{\beta}^0$ is the vector of the calibrated parameters equal to zero.

Other formal tests can be adopted, such as the Chi-squared test for the vectors of coefficients, the likelihood ratio test for the vectors of coefficients, and a test for the functional form of a model [30].

4. Results and Discussion

The experimentation aimed to test and validate the specified pre-test model reported in Section 3 and to test the validity in an extra-urban context. This section aims to investigate the willingness of users to use MaaS systems instead of private vehicles with a pre-test model in urban or extra-urban areas, as well as their willingness to pay to use an alternative to private vehicles with a pilot study.

The territorial context analyzed in the experiment was in the extra-urban area of Gioia Tauro in the Metropolitan City of Reggio Calabria in southern Italy. The 33 municipalities of the Gioia Tauro area were divided into five zones by merging neighboring municipalities. Considering the city of Gioia Tauro as the center of the study area, it is approximately 55 km from the Metropolitan City of Reggio Calabria. Approximately 150,000 people live in the Gioia Tauro area, while the extension of the territory is approximately 1000 km^2 with a density of approximately 150 inhabitants/km^2.

In accordance with [31], an indicative threshold was identified in order to be able to define an area characterized by low population density that corresponded to 50 inhabitants/km^2: 9 municipalities out of 33 belonging to the study area were below this threshold. In the study area, the transit mobility services consisted of road services and rail services. The former consisted of buses, car sharing, on-call services, and bike sharing. The road bus services were managed by approximately 15 companies. The rail services were managed by one company. The transport systems in the area were low-frequency transit. In some timeslots, was not possible to reach a destination by transit transport. For this reason, it was decided to study the possible introduction a MaaS system in the area and to analyze user preferences.

4.1. Scenarios and Survey

A survey aimed at a pilot sample of users was designed and carried out.

The survey form had 22 questions grouped into three sections:

- Macro-user data, such as age range, number of household members, and vehicle availability.
- The most frequent journeys, origins, destinations, methods, and frequencies of use of local public transport systems.
- What-if scenarios (Table 2).
    a. Scenarios 1 and 2 were (extra-urban) long distances (from the Gioia Tauro area to the Metropolitan City of Reggio Calabria and vice versa):
        i. Scenario 1 considered trips between the Gioia Tauro area and the Metropolitan City of Reggio Calabria in extra-urban areas.
        ii. Scenario 2 was the same as scenario 1, considering also that, in the present configuration, users pay a monthly subscription for parking a car. This was asked to understand if a user would prefer to pay for parking rather than buying a MaaS package, as in the previous case.
    b. Scenario 3 (suburban) was a short distance (inside the Gioia Tauro area) considering trips within the Gioia Tauro area in suburban areas.

Table 2. Services considered in the bundling of subscenario B.

Area—Distance Scenarios (Sub Scenario B)	Extra-Urban—Long Distance 1	 2	Sub-Urban—Short Distance 3
Suburban Bus (Monthly Subscription)	1	1	1
Urban Bus (Monthly Subscription)	1	1	0
Car sharing (30 min)	4	4	4
On-call service (h)	0	0	2
Bike Sharing (Two days mobile)	2	2	2
Train (Monthly Subscription)	1	1	0
Bundle Cost for MaaS (EUR/month)	135	135	90

Each scenario (1, 2, and 3) included three subscenarios (A, B, and C) with different services at different costs. Subscenario B considered a 33% reduction in cost (EUR/month) compared to the fare for individual services. Table 1 shows the services considered for subscenario B. The cost (EUR/month) and the frequency of subscenarios A and C compared to subscenario B were assumed as follows:

- In subscenario A, by reducing the price of the package by 25% and the frequency by 50%.
- In subscenario C, by increasing the price by 25% and the frequency by 50%.

The pilot sample included 21 users living in the study area. The sample size was within the range expected for this type of pre-test and pilot study. Small samples (between 10 and 30) in pilot and exploratory studies have the advantages of economy, simplicity, and easy calculation [32]. In [33], some considerations regarding the confidence intervals evaluated by pilot studies were reported; a sample size of 10–40 individuals per group can be used for a variety of objectives.

The survey was carried out for the sample group by experts in the transport area and MaaS. The experts showed the users the scenarios and their bundles. The questionnaire was not disseminated through a computer system with an automatic procedure, obtaining a large sample. The presence of an expert during the interview made it possible to clarify some questions posed by the interviewees on the subject and allowed us to obtain more reliable responses. Users spent at least 30 min of their time listening to an explanation of MaaS and were able to ask the experts for clarification.

For compatibly within the small size of the sample, the users interviewed were adults with an average age similar to that of the entire population. Furthermore, in order to obtain the majority of users from the extra-urban area of Gioia Tauro, approximately 71% had a systematic origin of trips in the area of Gioia Tauro, and the others had systematic origins in the remaining area of the Metropolitan City of Reggio Calabria.

The answers were treated anonymously. For this reason, for example, age was not asked but the users were simply asked to place themselves within one of the established age groups. In addition, the origins and destinations of journeys were asked in terms of zone. Users were asked to answer regarding their most frequent journey for the presented configurations of the three what-if MaaS scenarios (1, 2, and 3) and sub-scenarios (A, B, and C). For each scenario (1, 2, and 3), users were asked whether or not they were willing to buy options A, B, and C (yes or no for each subscenario).

To support the model specification, calibration, and validation phase, a statistical analysis of the results deriving from the survey was carried out. In relation to the reason for the usual journey, 24% made their usual journey for "Study" and 33% for "Work". In relation to mode, 76% used a private car.

Considering a one-way trip and the survey data, in scenarios 1 and 2 (extra-urban) the average travel time was 80 min and the average distance travelled was 60 km; in scenario 3, the average travel time was 30 min, and the average travel distance was 30 km.

4.2. Specification

In each scenario, each user expressed one preference for each subscenario (A, B, or C), and for each subscenario, a binomial Logit preference model was specified. The expected utility value associated with each subscenario preference had the following specification:

$$\begin{gathered} V_{si}/\theta = \beta_{bundle\_cost} \bullet bundle\_cost + \beta_{age} \bullet age + \beta_{scenario} \bullet scenario + \beta_{constant} \\ V_{no}/\theta = \beta_{time} \bullet time \end{gathered} \tag{9}$$

where

- β_{bundle_cost}, β_{age}, $\beta_{scenario}$, $\beta_{constant}$, β_{time} are the parameters to be calibrated.
- *bundle_cost* is the cost of the bundle in a specific subscenario.
- *age* is equal to 1 if the user is younger or equal to 45 years and 0 if older.
- *scenario* is one if the user prefers more than one subscenario in the scenario and zero otherwise, and the variable can be considered as a label.
- *time* is the sum of the access or egress time, waiting time, and travel time from the origin area to the destination area of the user's usual journey.

4.3. Calibration

For each scenario, four specifications (identified as I, II, III, and IV) were calibrated. The results derived from the maximum likelihood method are reported in Table 3.

Table 3. Values of the calibrated parameters.

Scenario (1..3)	ID (I..IV)	β_{time} (Util/h)	β_{bundle_cost} (Util Month/€)	β_{age} (Util)	$\beta_{scenario}$ (Util)	$\beta_{constant}$ (Util)	ln(likelihood) * (Optimal β)	ρ^2 [0, 1]	VOT (Euro/h)
1	I	−1.883 (−2.914)	−0.013 (−3.257)				−37.2	0.14	150
	II	−1.586 (−2.327)	−0.016 (−3.294)	0.921 (1.409)			−36.1	0.17	100
	III	−1.706 (−2.185)	−0.052 (−3.920)			5.573 (3.345)	−30.2	0.30	33
	IV	−0.658 (−0.686)	−0.078 (−3.843)		3.874 (3.138)	8.391 (3.541)	−21.8	0.50	8
2	I	−0.545 (−0.975)	−0.002 (−0.782)				−43.2	0.01	218
	II	−0.121 (−0.196)	−0.005 (−1.449)	1.023 (1.746)			−41.6	0.04	22
	III	−0.203 (−0.302)	−0.042 (−3.693)			6.137 (3.631)	−34.4	0.20	5
	IV	−0.392 (−0.472)	−0.066 (−3.738)		3.453 (3.432)	7.049 (3.245)	−24.4	0.44	6
3	I	−2.199 (−3.231)	−0.021 (−3.438)				−36.0	0.17	105
	II	−1.745 (−2.348)	−0.034 (−3.674)	2.056 (2.639)			−31.3	0.28	51
	III	−2.213 (−2.582)	−0.093 (−4.090)			6.479 (3.547)	−27.6	0.36	24
	IV	−1.027 (−0.991)	−0.128 (−3.956)		3.403 (2.887)	8.822 (3.680)	−21.2	0.51	8

* ln(likelihood) = −43.7 with parameters equal to zero. For each parameter, the results of *t*-test are presented in parentheses.

4.4. Validation

The time parameter had a negative sign (present in the no alternative). In fact, as time increased there was a greater propensity to choose the MaaS alternative. The bundle cost parameter had a negative sign because the higher the bundle cost, the lower a user's propensity to purchase MaaS packages. The scenario parameter state had a positive sign because the utility increased with the number of subscenarios chosen. All the calibrated models were acceptable in terms of the signs of the parameters.

The VOT varied from a maximum of EUR 150 to a minimum of EUR 8 for scenario 1, from a maximum of EUR 218 to a minimum of EUR 6 for scenario 2, and from a maximum of EUR 105 to a minimum of EUR 8 for scenario 3. The best results were those characterized by a low VOT, consistent with the users surveyed who traveled for work, study, or other reasons, such as errands or leisure. The best calibrated models in term of VOT were III and IV.

The Student's *t*-test established that a parameter estimate was significantly non-zero if the value did not belong to the range between −1.96 and +1.96 with the statistical significance of 95%, assuming that the value was distributed according to a standard normal variable [30]. In the calibration of scenario 1, according to this formal test, the β_{age} of model II and the β_{time} of model IV were not significant. In the calibration of scenario 2, on the other hand, the β_{bundle_cost} was significant, as well as the $\beta_{constant}$ of model III and the β_{bundle_cost}, $\beta_{scenario}$, and $\beta_{constant}$ of model IV. In the calibration of scenario 3, the parameters were all obtained as significant except for the β_{time} of model IV.

The indicator ρ^2 was zero if two functions were equivalent, and it was one if instead a model predicted a probability equal to one when observing the choice actually made and declared by each user. Therefore, if ρ^2 was 1, the model reproduced the choices of the sample [30]. The highest ρ^2 was obtained with the specifications of IV for the three scenarios. Some calibrations had very low indicator values but are reported to provide comprehensive and comparable information across different scenarios and subscenarios.

4.5. Probability and Elasticity

Figure 1 shows the variability in the MaaS preference probability with specification I for scenarios 1 (black line), 2 (red line), and 3 (blue line) and subscenarios A (continuous line), B (dotted line), and C (pointed line). The long-distance scenarios (1 and 2) are reported in Figure 1a while the medium-distance scenario (3) is reported in Figure 1b.

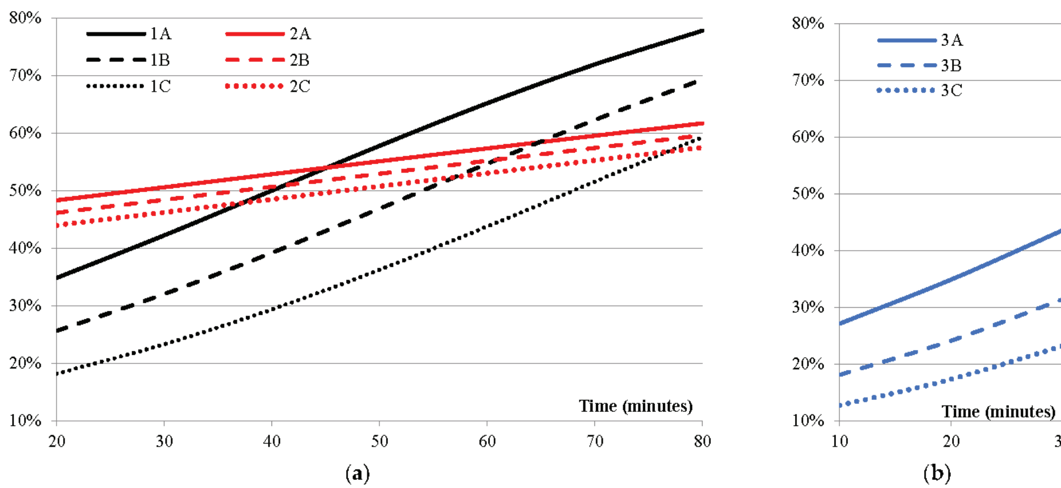

Figure 1. MaaS choice preference (%) with calibration model I: (**a**) scenarios A and B (long distance) and (**b**) scenario C (short distance).

The MaaS preference probability increased with travel time in the current alternative (negative value of the time parameter in the current alternative's utility) and decreased with increasing bundle cost (negative value of the parameter of cost in the MaaS alternative). The MaaS preference probabilities had similar values for scenarios 1 and 2 with the same travel time. Scenario 3 had a shorter travel time and had lower preference than scenarios 1 and 2. This result provided information on users and how they behave similarly for short and long distances in the absence of additional parking costs in the presented scenario. The elasticity values evaluated as the ratio between the percentage change of the probability and the percentage change of time were approximately 0.65 for scenario 1, 0.15 for scenario 2, and 0.75 for scenario 3.

In the case of the cost of parking, the behavior was different. In fact, for scenario 2, compared to scenarios 1 and 3, the probability of preference for the MaaS scenario started from higher values for low time values and grew less rapidly. The probability had a narrow range of variation compared to other scenarios with fixed travel times. The cost of additional parking greatly favored preference for the MaaS scenario.

4.6. Discussion

Most of the MaaS literature reported in Section 2 referred to urban areas characterized by high-frequency and multimodal transport services. In this paper, the attention has been shifted from the urban to the extra-urban context characterized by weak transport demand

and low-frequency transport services. The main objective of the paper was to propose a pre-test model for a preliminary evaluation of a MaaS system in an extra-urban context.

The proposed pre-test model had general validity in terms of specification and can be used to evaluate choice preference for the introduction of a sustainable MaaS system when an immediate response is required with a limited budget. The experimentation was carried out through a pilot sample and, therefore, can be used in the study area as a pre-test model in the feasibility step for the wider planning process of transport systems.

Considering also that this was a pilot survey and a pre-test model, the results can give some policy indications to decision takers and decision makers in the study area. Decision takers can use the pre-test model and the pilot study for support in the decision to proceed or not with the planning of a MaaS system through more extensive and in-depth studies. Decision makers can use the model and the pilot study for the design of an extended investigation and the calibration and validation of more advanced models in relation to the objectives and goals defined by decision takers.

A sustainable MaaS system cannot be achieved by adopting existing services and integrating them only through an information and communication technology system. A sustainable MaaS system must be planned and designed through the use of quantitative methods and models used in transportation engineering for estimating performances with simulations of user behaviors to achieve sustainable goals.

If it is necessary to evaluate the realization of a transport service that does not exist in a study area and is not present in similar territories, a survey using a large sample that builds detailed transport models can require significant implementation times and costs. The pilot sample and the pre-test model proposed in this paper fit into the preliminary evaluation phase when decision makers and decision takers want to understand if a system can be implemented and what to focus on for subsequent evaluations. The sample size considered in this paper was in the range considered for pre-test and pilot studies ([32,33]).

The model calibrated reproduced quite well the choices declared by users during the survey. In confirmation of what has emerged from other analyses mentioned in the text, bundles were more attractive for users who made journeys characterized by longer journey times and were less so for those who made short journeys. The attractiveness grew with the travel time and decreased with the cost of the package. The additional cost in the present scenarios influenced the preference for bundle cost. Considering the parking cost in a presented scenario (scenario 2), the MaaS preference probability started from higher probability values but increased less quickly.

The results obtained in terms of statistical indicators confirmed that with a pilot sample and the calibration of a pre-test model, preliminary information could be obtained regarding the possible feasibility of a MaaS system and the relevant variables to be further analyzed by means of a wider investigation and the calibration of a more in-depth model.

A pilot sample of users was considered and the following results obtained are to be considered preliminary and referred to the extra-urban context analyzed: the MaaS preference has a high variability, from 20% to 80%, and requires further investigation considering the small sample size; the MaaS preference increases with the travel time of the chosen travel alternative without the presence of the MaaS system; the elasticity is slightly influenced by travel time and is strongly influenced by price; and the MaaS preference is also influenced by a preference of the sample users towards MaaS, not directly linked to travel time and price.

5. Conclusions

In this paper, a Logit model was proposed for evaluating the preference for MaaS in an extra-urban context with weak demand. The model was specified, calibrated, and validated using a small sample size. The main purpose of the paper was to evaluate the possibility of using a model of this type for the design of a future, more extensive investigation. The model was considered as a pre-test model. The specification had general validity. The attributes to consider in utility had to be selected case by case. Even the calibrated parameters and the relative numerical results were valid only for the specific case study in a pre-test model phase.

The model was tested in the area of Gioia Tauro in the south of Italy. In the study area, shared mobility services, such as bike sharing and car sharing, were not widely available. This was confirmed during the pilot survey by the interviewees: 76% traveled in their own cars, 38% never used public transport, and only 5% used local public transport every working day. In the survey, three MaaS scenarios (named 1, 2, and 3) each with three subscenarios (named A, B, and C) with increasing frequency of transport services and bundle cost were proposed to users. From the pilot survey, a Logit model was calibrated and validated with the maximum likelihood method considering four specifications for each scenario (I, II, III, and IV). In the first specification, two parameters were calibrated: one referring to time and one referring to cost. In the second specification, the age parameter was also calibrated. In the third specification, the constant parameter was calibrated with respect to the first specification. In the last specification, the label relative to the scenario was calibrated with respect to the third specification. From the first to the fourth specification, the VOT decreased while the ρ^2 increased. Consistent with the class of users surveyed, the fourth specification had better results, but the time parameter was not statistically significant based on a Student's *t*-test at a 95% confidence level.

In the case study, for long-distance journeys without parking payment in the current scenarios and for short-distance journeys, the elasticity was approximately 0.65, with highly variable preference probabilities (MaaS preference between 20% and 80% increasing with travel time). For long-distance journeys with parking payment in the current scenarios the elasticity was approximately 0.15 (MaaS preference around 50% slightly increasing with travel time).

These results indicate that the preference for MaaS grew with the increase in travel time and was strongly influenced by the price of the bundle. From the utility specifications, it can be observed that the inclusion of the 'scenario' variable led to a significant increase in the ρ^2 statistic (from 0.30 to 0.50 in scenario 1, from 0.20 to 0.44 in scenario 2, and from 0.36 to 0.51 in scenario 3). This variable had a positive sign in the calibrations in the case study. It was a label and an indicator of the preferences of sample users toward MaaS, and the variable was not necessarily linked to service-level variables.

The model has limits to be developed in future works. It was based on a pilot sample and, due to the small number of interviews, it was not possible to calibrate a greater number of parameters or other typology of random utility models, which would have allowed us to obtain a greater amount of information relating to MaaS.

The model must be considered as a pre-test model useful for designing a larger sample and a more general preference model. This work should be considered preliminary and could be the basis for building a MaaS preference model and carrying out a larger survey in order to calibrate a greater number of parameters considering the results obtained in this paper. Furthermore, other types of choice models could be specified and tested, as well as considering possible covariance between alternatives.

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A Comparison of Urban Planning in Eastern Asian Capitals during Japanese Colonial Rule: Tokyo, Taipei (1895), Seoul (1910), and Beijing (1936)

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Abstract: Japan's urban planning system began with the Urban Renewal (1885) and has been modified since then in various ways through the Tokyo City Improvement Ordinance (1888) and the City Planning Law (1919). From 1895 to 1945 (Japanese colonization era), Japan applied and tested its urban planning in Taipei (1895–1945), Seoul (1910–1945, Gyeongseong), and Beijing (1936–1945). Although Tokyo was the first city discussed for planning, urban renewal was implemented in other colonized cities in a similar period. What Tokyo, Seoul, Beijing, and Taipei have in common is that they are built around fortress walls. Hence, the present study aims to examine the characteristics of Tokyo's urban planning and reveal how Japan's urban planning transformed these cities in East Asia, which had different cultures and styles, during Japanese colonial rule. We analyzed urban renewal projects implemented in each city, the organization of a committee to plan the City Planning Ordinance, the effect of urban planning, the characteristics of urban planning, and changes in existing downtowns.

Keywords: Beijing; City Planning Law; East Asia; Japanese colonial rule; Seoul; Taipei; Tokyo; urban planning; urban renewal

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1. Introduction

1.1. Research Purpose and Preceding Research

Japan's urban planning system has changed in various ways through the Tokyo City Improvement Ordinance (1888) and the City Planning Law (1919). From 1895 to 1945 (Japanese colonization era), Japan applied and tested its urban planning in Taipei (1895–1945), Seoul (1910–1945, Gyeongseong, reported as Seoul in the text except for the maps and laws), and Beijing (1936–1945). The present study aims at examining the characteristics of Tokyo's urban planning and revealing how Japan's urban planning transformed these cities in East Asia, which had different cultures and styles, during Japanese colonial rule (see Figure 1).

There has been a pile of previous studies on each city's urban planning during Japanese colonial rule. Studies on Tokyo's urban planning include Yorihusa Ishida's study on the history of Japan's land readjustment systems [1], Akira Koshizawa's study on Tokyo's urban planning [2], and Terunobu Fujimor's study on urban planning in Tokyo [3].

Studies on Seoul's urban planning during Japanese colonial rule include Koshizawa's study on social capital rebuilding [4], Son Jung-mok's historical study [5], Yasushi Goto's study on street renewal in Seoul [6,7], and Yum Bok-gyu's study on urban planning process and urban expansion [8].

Studies on Taipei during Japanese colonial rule include Koshizawa's study and Hwang Se-maeng's historical study [9,10] and Goto's study on the formation of households in

Taipei [11–13]. Studies on Beijing include Koshizawa's historical study [14] and Yoon Hyung-jin's study on urban planning [15].

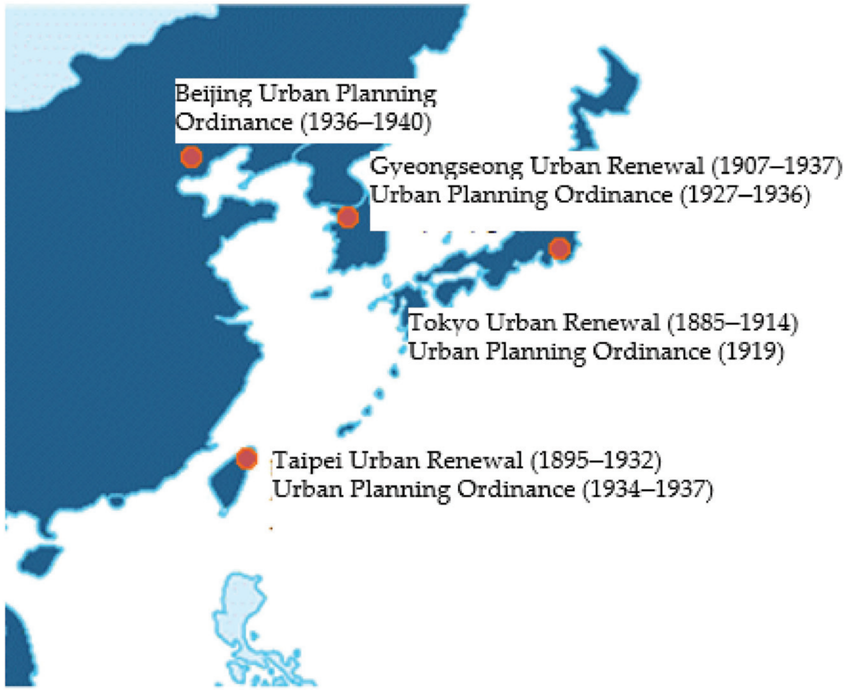


Figure 1. Research sites.

Comparative studies include Goto's research on the system of urban renewal in Seoul and Taipei [16,17]. Goto analyzed the changed use of spaces due to the collapse of feng shui geomancy and explained the renovation and formation of downtown Seoul and Taipei as urban renewal. Bae Hyun-mi's comparative study focused on the formation of downtowns in Korea and Japan [18] and Kim Baek-young's comparative study investigated urban renewal in Seoul and Tokyo [19]. Goto's study compares each ordinance's establishment process and practical differences in Joseon's Seoul, Taiwan's Taipei, and China's Dalian and Manchuria under colonial rule [17].

Prior studies have either focused on various topics of cities under Japanese colonial rule or compared them to Tokyo. The capitals of East Asia possess the characteristic of being traditional cities prior to Japanese colonial rule. This study aims to uncover the distinct characteristics of urban planning by comparing and analyzing the effects of Japanese urban planning on the capitals of East Asian countries during the colonial era.

1.2. Research Method

As a way to understand things, it can be useful to classify them one by one and grasp the meaning of each object, rather than recognizing the whole as a single entity and establishing relationships between them. Analytical methods that categorize objects individually, quantify them, and study them quantitatively are widely used.

Analyzing involves comparing and classifying the properties of objects, identifying their relationships accurately, and ultimately determining their properties. Interpretation involves identifying the meaning of causes, processes, results, and reasons based on special facts, viewed from the perspective of probabilism rather than determinism. It is a task that differs from the analytical method. In particular, when dealing with complexly intertwined elements, such as in a city, taking a holistic approach and recognizing the whole as one entity is often more effective.

Therefore, in this study, a holistic and interpretive approach is used, rather than an analytical approach. The purpose of the study is to identify the similarities and differences in how urban planning and development methods were applied to Tokyo, the capital of Japan, during the Japanese colonial period, and to its colonies Taipei, Seoul, and Beijing. The interpretative method is judged to be more effective for this purpose. The study reviews the existing urban planning laws and development methods for each city, including studies and references that examine actual applied cases. For the overall interpretation, maps of each city era are compared at the same scale. However, the lack of figures or graphs compared to analytical and quantitative research methods is considered a limitation of the interpretive method.

2. Modern Urban Planning in Tokyo

2.1. Tokyo Urban Renewal

Although Tokyo, which had been an administrative capital for 415 years, had good sewage works, the city needed to prepare against fire in densely located wooden buildings, build sanitation works and roads, and rebuild infrastructure as a modern city. Edo was the predecessor of Tokyo and was comprised of Musashi, Sasaji, and Choningji, centered around Edo Castle. As it was situated along the waterfront for water transportation, its location was favorable in terms of topography, but it did not take into consideration Feng Shui, unlike other traditional cities [20].

By the Meiji period (1868–1912), a need to overhaul Tokyo had been recognized, and Governor Matsuda Michiyuki planned to renovate roads and streams in the areas lost to a fire in 1879 [21]. In 1885, Governor Yoshikawa Akimasa established the Tokyo Urban Renewal Review Committee in the Home Ministry and planned to build railroads, ports, and parks, but the project was not realized [21]. In the same period, Inoue Kaoru from the Ministry of Foreign Affairs created the Temporary Construction Bureau and established the 'Government Agency Focus Plan' [19]. To plan water and sewage works as part of the Government Agency Focus Plan, James Hobrecht was invited from Germany in March 1887 [3]. In addition, William K. Burton was hired in the Sanitary Bureau of the Home Ministry in 1887 and put in charge of the primary plan for water and sewage works not only in Tokyo but also Kobe, Fukuoka, and Okayama. On 16 August 1888, the Home Ministry announced the Tokyo City Improvement Ordinance and established the Tokyo Urban Renewal Committee [21]. Regulations on buildings were reviewed at that time but not included. In 1889, the proposed plan was made public, but could not make progress due to funding problems and was eventually cut significantly in 1903. After the Russo–Japanese War, the Temporary Urban Renewal Bureau was established in Tokyo in 1906, and the Urban Renewal Plan was completed in 1914 as originally intended in 1903.

2.2. City Planning Law

While urban planning focused on how to modernize the city in the 19th century, a discussion on how to expand it was a major challenge in the 20th century. In 1919, the first modern City Planning Law and Urban Building Code were signed into law. The objectives of the City Planning Law as an extension of the Tokyo City Improvement Ordinance (1888) were to expand the city, planned areas, planned items, funding sources, and land expropriation. Compared to the Tokyo City Improvement Ordinance, it established the way of thinking that urban planning is a comprehensive overhaul of the entire city. It was more progressive as it created limits, zoning, land readjustment, structure expropriation, and benefit principles in urban planning and recognized overcapacity [2].

With the implementation of the City Planning Law, the Tokyo Urban Planning Road Network was determined in May 1921, and Tokyo Urban Planning Zones were determined in April 1922. After the 1923 Great Kantō earthquake, Tokyo Mayor Gotō Shinpei, as Minister of Home Affairs and Governor of Imperial City Redevelopment, established the

Imperial City Redevelopment Plan that included land readjustment and the renewal of parks and main roads. Gotō was a political leader who ruled Taiwan in 1898 after he studied in Germany and returned home in 1890. After the Taiwanese Survey Project, he was appointed as the President of the South Manchuria Railway in 1906 and put in charge of building infrastructure for the South Manchuria Railway with Dalian as a hub, expanding sanitation works and constructing cities. From 1920 to 1923, he served as Tokyo Mayor and led Tokyo's Imperial City Redevelopment Plan based on his urban planning experience in Taipei and Dalian [22].

Since then, the Main Road Network was determined for Tokyo Urban Planning Zones in August 1927. Inside Tokyo, radial line and ring roads originating from Tokyo Station were planned with the focus on connecting and expanding Tokyo and its suburban areas outward. The City Planning Law enacted in 1919 was revised in March 1933 and it provided the basis to discuss urban planning for Joseon, Manchuria, and Taiwan.

2.3. Applicable Building Codes

Tokyo Urban Renewal Land and Building Disposition Regulations (1889) imposed limits on the land rights [21]. The proposed Tokyo Building Ordinance was planned in 1894 and 1913 but was not legislated. In 1919, the Urban Building Code was introduced nationwide.

3. Modern Urban Planning during the Colonization Era

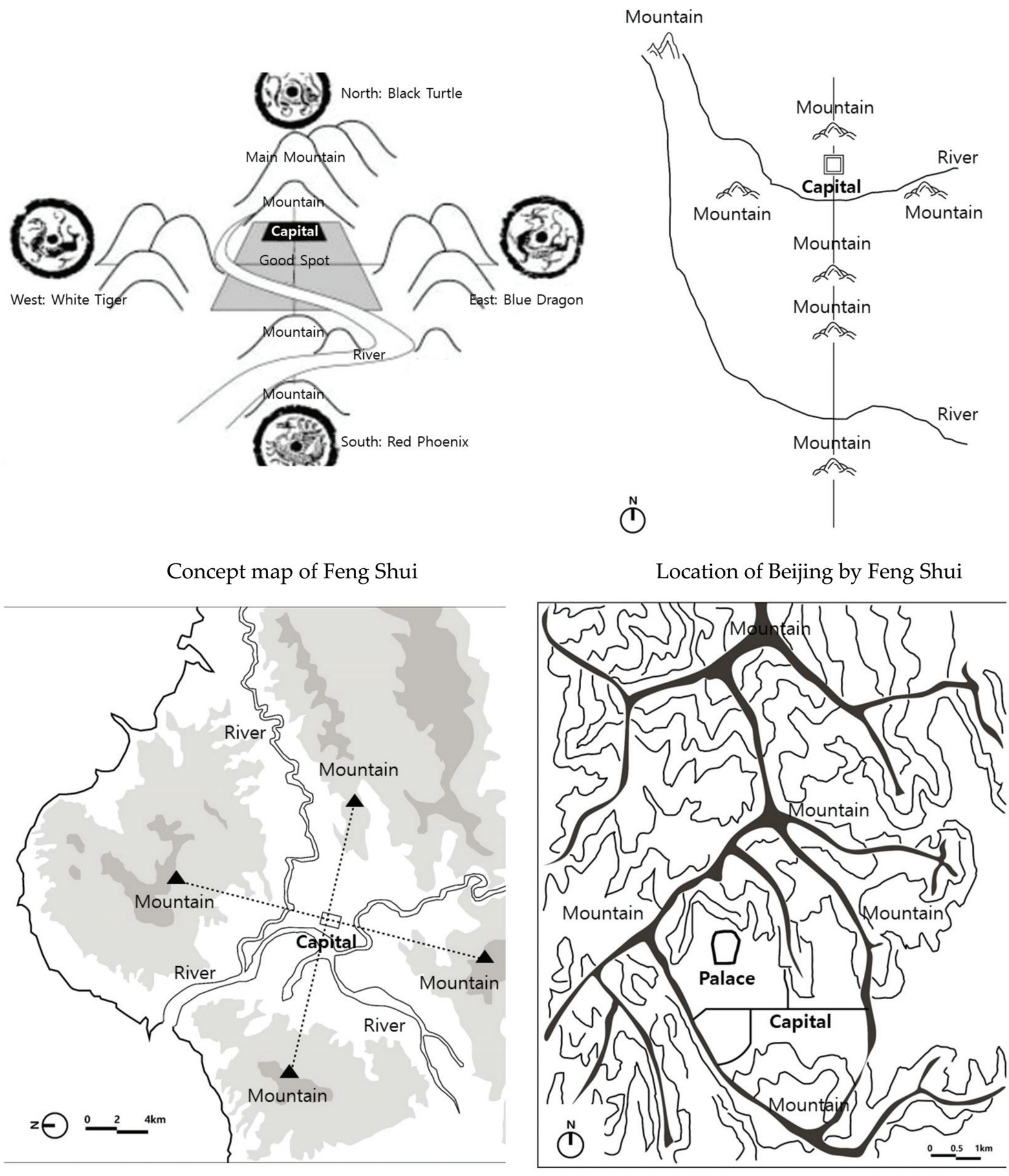
3.1. Taipei's Modern Urban Planning

3.1.1. Urban Renewal in Taipei

In 1895, Taipei had three downtowns: Monga, Dadaocheng, and Taipei City Walls. Monga and Dadaocheng had grown with water transport in a brine river, and the inside of Taipei City Walls was a government agency district built as a result of the establishment of Taipei Prefecture in 1874. Taipei City was planned and constructed at the end of the Qing Dynasty, and its design was influenced by the characteristics of Chinese traditional city planning and Feng Shui. The axis of the city was determined based on a specific mountain surrounding it, and the presence of the Four Gods demonstrates the influence of Feng Shui [23] (Figure 2).

Japan, to which Taiwan had been ceded from the Qing dynasty after the Sino-Japanese War, established the Government-General of Taiwan inside Taipei City Walls in 1896. At that time, Taipei had sanitation issues in downtowns. Under the leadership of Director Gotō of the Sanitary Bureau of the Home Ministry in Japan, W.K. Burton, an advisor for sanitation works, established an urban renewal plan with sanitation as a keyword.

Taipei's urban renewal was implemented over the course of six plans. The 1st Plan (1895) established temporary ditches around the city walls to prevent a flood inside Taipei City Walls when a brine river was flooded. The 2nd Plan (1896) invited Burton to ensure cleanliness and installed open channel sewage works. The 3rd Plan (1900) announced a road plan inside Taipei City Walls. The 4th Plan (1901) announced a decision for urban renewal near the south and east gates of the city walls to expand the downtown. The 5th Plan (1905) attempted to combine the inside of Taipei City Walls, Dadaocheng, and Monga to form a large city. Monga and Dadaocheng were designed in a way that made the best use of existing roads due to budget problems. It was planned to demolish the city walls and build 25–40 kan (unit of measurement) wide mountain roads in their place. Even though the 5th Plan estimated that the population would have reached its peak by 1932, the city had already grown to a population of 170,000 in 1922. Accordingly, the 6th Plan (1932) established an urbanization plan for 600,000 people. The 1932 Great Taipei Urbanization Plan was mainly about connecting roads to suburban areas and creating parks [24–26].



Concept map of Feng Shui

Location of Beijing by Feng Shui

Location of Taipei by Feng Shui

Location of Seoul by Feng Shui

Figure 2. Feng Shui concept map and application of each capital.

3.1.2. Taiwanese City Planning Law

The Taiwanese City Planning Law combined building and land readjustment laws with urban planning ones and improved upon Japan's City Planning Law. In September 1934, the City Planning Law Implementation Preparation Committee was established in the Government-General of Taiwan. After meetings in February and August 1935, the law was announced on 27 August 1936 and enforced from 1 April 1937. The Taiwanese City Planning Law included urban planning special taxes and benefit principles, based on which land expropriation, land readjustment, parks, streets, sewerage works, and zoning were set up. Unlike other countries, the Taiwanese City Planning Law had a unique provision that did not permit building outside the planned area. In addition, a provision that required buildings be connected to roads prohibited the construction of buildings in unplanned or unorganized areas [27].

The following aspects were improved institutionally from Japan's City Planning Law [25]. The scope of zoning was made consistent with the scope of areas under urban planning. It allowed the city to designate special districts in addition to commercial and residential ones. As improvements in land readjustment, only the landowner could readjust land, and in case of forced implementation, land was readjusted by authority from the Government-General of Taiwan. In addition, limits on personal property rights, which were only possible because it was a colonial city, enabled planned downtown expansion and control [24–26].

3.1.3. Applicable Building Codes

In the 1890s, the Longhouse Construction Rules were established across many parts of Japan and, on their basis, the Taipei Housing Construction Rules (25 November 1896), applicable to Japanese people living in Taiwan, were enforced. On 29 April 1897, the Government-General of Taiwan organized the Taipei Urban Renewal Committee as a body that reviewed urban renewal and sanitation works [17]. The Taipei Urban Renewal Committee enacted the Taiwanese House Construction Rules in August 1900, which had been used until 1936, when the Taiwanese City Planning Law was announced [17]. While it had some differences in terms of dimensions from Japan's Longhouse Construction Rules, other construction regulation items, including building lines, fire protection, and sanitation works, were almost the same [27].

3.2. Seoul's Modern Urban Planning

3.2.1. Urban Renewal in Seoul

The predecessor of Kyungsung was Hanyang during the Joseon dynasty. Hanyang was designed under the influence of Feng Shui, and the arrangement of spaces such as Jongmyo Shrine, Sajikdan Alter, the palace, and government offices were influenced by the Chinese capital-city system based on Kaogongji. Jongmyo (1395) is the supreme state shrine where the royal ancestral tablets of deceased kings and queens are enshrined, and sacrificial rites are performed for them. Sajikdan Altar is an ancient altar for memorial services whose name, 'Sajikdan', means to 'pray for the comfort and prosperity of the country and its people' [28] (Figure 2).

With the Japan–Korea Treaty of 1904, Japan gained the right to provide administrative advice and turned Korea into a protectorate under the Eulsa Treaty in 1905, establishing the Japanese Resident-General of Korea. Then, the Government-General of Joseon was created after the Japan–Korea Annexation Treaty in 1910. Seoul's urban renewal aimed at improving transport convenience and renewing the city's outer look, as shown by the focus on renovating roads and the fact that the project was expedited to show off before the Joseon Industrial Exhibition in 1915 and the Joseon Exhibition in 1929.

In Seoul, urban planning was led by administrators, and urban renewal was implemented by Itō Hirobumi, the Resident-General of Korea at that time [7]. Urban renewal implemented by the Resident-General of Korea began with Namdaemun Road Rebuilding in 1907 to operate trams. The Government-General of Joseon rebuilt the remaining parts of Gold Town Street as part of the State-funded road paving in 1911 and put forward the notice 'Line 29 Planned for Urban Renewal' in 1912 [7]. The plan arranged grid roads, a circular square, and radial line roads around Jongno and Namdaemun. Roads in the south and north directions were mainly rebuilt, and the only completed road in the east and west directions was a line connecting the square in front of Daehanmun, Gold Town Street, and the outside of Gwanghuimun. Urban renewal was not implemented for the roads which had already enough width.

In June 1919, urban renewal was launched, which included downtown expansion around Yongsan and Mapo and revisions to the original plan. Roads connecting to Yongsan were added, and streets placed radially around the square were removed. Instead, radial line roads in front of Gwanghwamun were newly added.

Due to financial reasons, the urban renewal project had been transferred from the Government-General to Gyeongseong Prefecture since 1929 [8]. According to Gyeongseong Downtown Planned Street Network Map in 1936, the number of streets reached 220 and roads from inside the fortress walls were rebuilt and connected to other cities.

3.2.2. Joseon City Planning Ordinance

The Joseon City Planning Ordinance was Korea's first modern city planning law enacted in 1934. In 1936, the Joseon City Planning Ordinance applied to Kyungseong Prefecture, following Najin. In December 1936, the Kyungseong Downtown Planned Street Network Map was determined with No. 722. In Joseon, there was some movement for the City Planning Ordinance in 1922 when the Internal Affairs Bureau of the Government-General drew up a draft city planning law, but it had been discontinued for quite some time [8]. In December 1927, it was re-discussed as Governor-General Yamanashi Hanzō of Korea and Inspector-General Shirou Ikegami of Political Affairs were inaugurated [8]. Ikegami served as Osaka Mayor and attempted urban planning several times in Japan. In January 1928, the Urban Planning Research Association filed a motion to implement a 'complete city planning law' which included the Urban Planning Committee, land readjustment, zoning, and benefit principles [8]. Okazaki Shotaro, who was a renowned figure in urban planning, was invited and the Joseon Downtown Planning Ordinance was completed in July 1931 [8]. However, since the second half of 1931, right after Kazushige Ugaki was appointed as Governor-General, the direction of urban planning was changed due to Joseon industrialization policies, and discussions began again on the city planning law to accommodate the changed direction [8]. At that time, the City Planning Law was acknowledged in Japan as a tool for the State to efficiently mobilize resources such as land or population, not to tackle urban problems; therefore, the law was revised in a way that tightened control (Table 1). As the City Planning Ordinance was proposed, the Temporary Urban Planning Section was reorganized into the official Urban Planning Section under the Department of Civil Works, and the Kyungseong Urban Planning Survey Committee was organized in July 1933. While the original City Planning Ordinance followed the Japanese legal system, it accepted opinions on 'matters required to rule Joseon and ensure industrial status,' and a draft was completed in the early 1933 and announced in June 1934, after government review in homeland Japan [29]. It was mainly about items subject to urban planning, authority for urban planning, land readjustment, and zoning. Compared to the lines planned for urban renewal, this phase expanded the planned areas and adopted the metric system as a unit for street width as per regional expansion under Government-General Ordinance No. 8 on 14 February 1936. The Joseon City Planning Ordinance was characterized by the fact that it mainly focused on setting up planned streets and land readjustment districts. The ordinance emphasized that it was a national project, granted all decision-making and enforcement rights to the Governor-General, and did not establish an advisory body with legal status, unlike Japan. For zoning, it set forth unspecified areas that had no particular aims as well as industrial, commercial, and residential areas.

In Japan, Seoul urban planning was evaluated as advanced 'Even though the administrative agency needs to implement this urban planning project all together since Joseon has a lack of knowledge and experience and its people's level is low' [30]. In addition, it was also assessed that 'There is little progress in land readjustment projects in Japan since there are too many discussions as associations implement them, but this project is expected to make smooth progress in Joseon as it is implemented by the State' [31].

Table 1. Major enforcement event of urban renewal plan and city planning law in Tokyo, Taipei, Seoul, and Beijing(Light Gray: Urban renewal, Dark Gray: City planning law).

	Tokyo	Taipei	Seoul		Beijing
1885	Urban Renewal Review Committee				
1888	Urban Renewal Ordinance/Urban Renewal Committee				
1889	Proposed Urban Renewal Plan				
1895		1st urban renewal			
1896		2nd urban renewal			
1897		Organized the Taipei Urban Renewal Committee			
1900		3rd urban renewal Taiwanese House Construction Rules			
1901		4th urban renewal			
1903	Reduced the plan				
1905		5th urban renewal			
1906	Temporary Urban Renewal Bureau				
1907			Resident-General urban renewal		
1911			Road Rules; Land Expropriation Ordinance; Downtown Building Control Rules		
1912					
1914	Completed an urban renewal plan				
1919	City Planning Law; Urban Building Code				
1921	Urban Planning Road Network		Government-General urban renewal (1928)		
1922	Urban Planning Zones				
1923	Imperial City Redevelopment Plan				
1927	Main Road Network in Urban Planning Zones			Discussed the Joseon City Planning Ordinance	
1928					
1929			Gyeongseong Prefecture Urban Renewal (1937)		
1932		6th urban renewal Great Taipei Urbanization Plan			
1933	Revised the City Planning Law			Gyeongseong Urban Planning Survey Committee	
1934		City Planning Law Implementation Preparation Committee		Announced the Joseon City Planning Ordinance	
1936		Announced the Taiwanese City Planning Law		Applied the Joseon City Planning Ordinance to Gyeongseong Gyeongseong Downtown Planned Street Network	
1937		Implemented the Taiwanese City Planning Law			
1938					City Bureau under the General Office of Construction; Beijing Urban Planning Outline
1940					Urban Construction Tentative Rules

3.2.3. Applicable Building Codes

The first building code introduced in Korea was applied to Japanese people living in Joseon such as Taiwan. The implementation of the building code began in residential areas for Japanese people in opened ports, and the scope of the law broadened as the residential areas of Japanese people spread more widely. Unlike opened ports, no law governing buildings was found for Seoul, and roof material regulations for fire protection and house regulations for parts in contact with roads were put in place [27]. On 17 April 1911, the Road Rules and the Land Expropriation Ordinance were applied. In February 1913, Government-General Ordinance No. 11 Downtown Building Control Rules was issued. The Downtown Building Control Rules were set up without direct relations to urban renewal. The rules defined building coverage ratio, building lines, building materials, associated facilities, aesthetics, and disaster prevention. The Downtown Building Control Rules were incorporated into a single urban building code by the Joseon City Planning Ordinance in 1934.

3.3. Beijing's Modern Urban Planning

3.3.1. Beijing Urban Planning Outline

The Beijing Wall was expanded and transformed over time into the Jungdo of the Jin Dynasty, the Daedo of the Yuan Dynasty, and finally the Beijing Castle of the Ming and Qing Dynasties. The city's layout is based on the principles of Kaogongji and reflects Confucian and Feng Shui values in its placement [32] (Figure 2).

After Japan took over Beijing in 1937, the Japanese population was increasing at a rapid pace, which subsequently raised needs for infrastructure and residential buildings. In addition, as Japan designated Beijing as an important base for military control and economy, urban planning and construction activities were conducted accordingly.

The Provisional Government of the Republic of China was established in December 1937, and the Reformed Government of the Republic of China was created in Nanjing in March 1938. Combining the two governments, the Reorganized National Government of the Republic of China was established with Wang Jingwei as a head of State. In 1938, the General Office of Construction was created in the North China Political Affairs Commission, and the City Bureau was placed thereunder [14,15]. In 1938, a plan was established by Sado Toshihisa and Yamazaki Keiichi, who led urban planning in Harbin [14,15]. In November 1938, Shiobara Saburo was sent to survey the city, and after a few proposals, the final version of Beijing Urban Planning Outline was determined [14,15].

The most distinctive feature of the Beijing Urban Planning Outline was that it was a new city-centered plan. Instead of the old city center, it focused on building new cities in western suburbs focused on administrative and residential functions and eastern suburbs designated as industrial districts. Meanwhile, it only emphasized the preservation of historical places or the maintenance of urban functions inside the city walls. For the construction of western and eastern suburbs, it was planned to build new cities away from the existing city, not to expand the old city center in Beijing [14,15].

As the war intensified, subsequent plans were put on hold. Nonetheless, the Beijing City Government continued to be successful in building new cities in western and eastern suburbs in the post-war period.

3.3.2. Applicable Building Codes

On 1 October 1940, the General Office of Construction announced the Urban Construction Tentative Rules and designated the rules governing zoning, building lines, and building form regulations.

4. Urban Planning Comparison

Beginning with Japan, modern urban planning proceeded with Taipei, Seoul, and Beijing, which were colonized by Japan, based on Tokyo's urban planning but with some updates and modifications. The present study compares the cities by each item from urban renewal to city planning law.

In Table 1, the light gray represents major events in city plan revision, while the dark gray highlights major events in city planning legislation. The introduction of the Urban Planning Act occurred in the order of Tokyo, Taipei, and Kyungsung, with Beijing being introduced later due to the delay in occupation. In regard to urban renewal, Taipei was ahead of Kyungsung, but ultimately, the City Planning Law indicates that Joseon was quicker. Table 1 illustrates where Japan's focus on urban planning was in East Asia during each period.

The purpose of urban renewal varies across the cities, and Tokyo's urban renewal was planned to facilitate the city's fire protection measures, sanitation, and transport convenience. Among the colonized cities, urban renewal was taking place at the fastest pace in Taipei, where it originally began with sanitation issues (Table 2).

Table 2. Comparison of Urban Planning in Tokyo, Taipei, Kyeongseong, and Beijing.

Comparison Item		Tokyo	Taipei	Seoul	Beijing
Urban renewal	Purpose	Fire protection measures, sanitation, transport convenience	Sanitation	Transport convenience, outer look	
	Planner Water and sewage works	Yoshikawa Akimasa James Hobrecht	Gotō Shinpei William K. Burton	Itō Hirobumi, etc.	
	Year of establishment of the committee	1885	1898	1921	
	Water and sewage works	Not linked	Linked	Not linked	
	Building code	Not included	Included (1900)	Not included	
City planning law	Year of establishment of the committee	1919	1934	1933	1938
	Year of promulgation of the building code	The City Planning Law and the Urban Building Code were enacted in 1919	Both in 1936	Both in 1936	1940
	Year of the establishment of the downtown expansion plan	1927	1932	1937	1938
	Planner	Gotō Shinpei	-	Governor-General, Resident-General	-

In Seoul, urban renewal was planned to provide transport convenience and create the outer look of a modern city. The Urban Renewal Committee, an organization for planning, was established in Tokyo in 1885, Taipei in 1898, and Seoul in 1921. In Taipei, sanitation issues such as pests emerged as one of the biggest problems. Gotō invited Burton to give advice on sanitation works and urban renewal was implemented, focusing on water and sewage works. One of the notable features of Taipei's urban renewal was that it was implemented from the 1st to the 6th Plan from 1895 to 1932. In addition, it began as a plan for water and sewage works and had expanded into road network and downtown expansion (Table 2).

Seoul's urban renewal was divided depending on who planned urban renewal into the one implemented by the Resident-General and the other by the Government-General. Furthermore, as urban renewal progressed, the City Planning Ordinance was planned at the same time. When planning urban renewal, all these four cities had a limitation that they reviewed the building code but did not include it (Table 2).

The committee for the city planning law was established in each of the cities: Tokyo in 1919, Seoul in 1933, Taipei in 1934, and Beijing in 1938. During this period, their city planning law included the building code. Tokyo's City Planning Law was led by Gotō, who initiated urban renewal in Taipei. Seoul's urban planning was led by the Resident-General, the Government-General, or the Inspector-General of Political Affairs. It is worth noting that Inspector-General Shirou Ikegami of Political Affairs formerly served as Osaka Mayer and led urban planning in Osaka (Table 2).

Hence, Tokyo's urban planning and that of Taipei, Seoul, and Beijing cities, colonized by Japan, influenced each other when they were established, as the people in charge were intertwined and involved in multiple cities [33].

5. Changing the Shapes of Traditional Cities through Modern Urban Planning Tokyo

Edo, a predecessor of Tokyo, was part of Musashi Province. Edo Castle was built in 1457 during the mid-Muromachi period, laying the ground for the city of Edo. Afterwards, as Tokugawa Ieyasu entered Edo in 1590 and established the bakuhan system in 1603, Edo was planned as a large jōkamachi (castle town) in response to the class system and economic activity in the feudal period (Figure 3). In the modern period, the Meiji government began to reshape Tokyo to ensure its reputation as a capital, prevent infectious diseases and large fires, and revamp transport facilities. With the Government Agency Focus Plan and the Ginja Brick Street Plan, Tokyo Urban Renewal, its first statutory urban planning, was implemented from 1889 to 1916. While it did not make further progress due to lack of funding, roads were expanded in the city center to operate trams, waterworks were rebuilt, and the Hibiya Park was created (Figure 4).

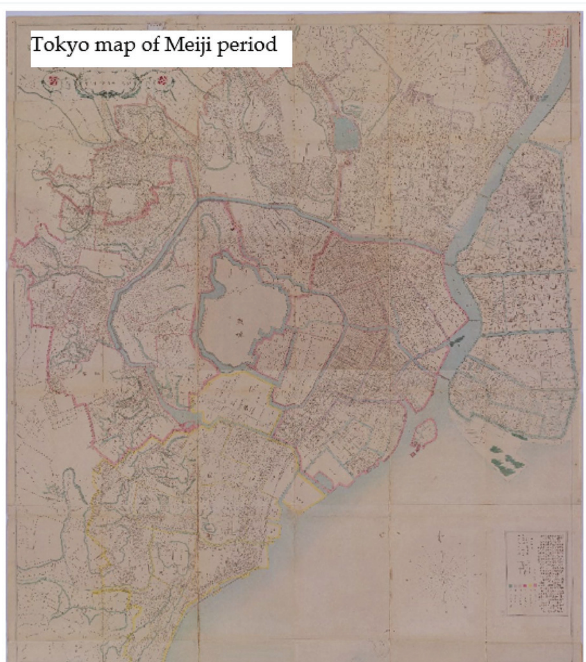


Figure 3. Map of the Traditional City of Edo (1876, Tokyo Metropolitan Archives).

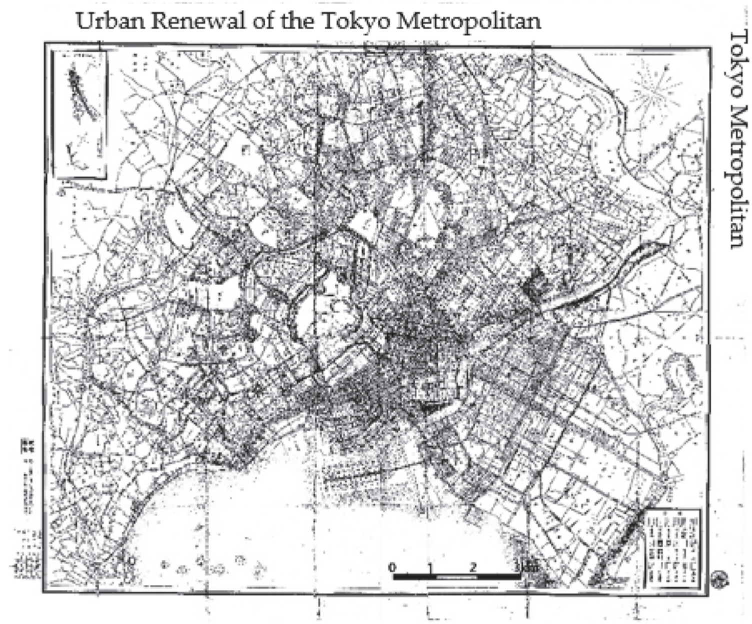


Figure 4. Map of Tokyo's urban renewal (1899, National Diet Library).

The scale of downtown Tokyo was not so different between the Edo period and the Meiji period. Land use in the Edo period was set by the class system, and transport means were limited to walking or litter. With urban renewal in the Meiji period, however, land use and transport means were transformed. Although the City Planning Law was announced in 1919, the progress in urban renewal projects was not significant. After the 1923 Great Kantō earthquake, Gotō rebuilt the city's infrastructure, including land readjustment, streets, bridges, and parks in the Imperial City Redevelopment Project.

Modern urban planning had the most significant effect on changing urban spaces when the traditional city of Edo transitioned into the modern city of Tokyo. Such urban planning was not governed by law at the beginning but implemented as part of urban renewal projects. A series of such projects was closely related to transport facilities in Tokyo and had proactively changed urban spaces. In Tokyo, Shimbashi Station was created in 1872, and the railway between

Shimbashi and Yokohama was built. Before that, the primary transport system in Tokyo was represented by horse-drawn carriages. In 1882, the Tokyo Stagecoach Railway was established, and while demands and discussions for trams continued, a decision by the Urban Renewal Committee for the Electric Railway Establishment Plan for 29 lines was made quite late in 1900, which was more delayed than other cities, due to disputes over patents between companies. The Urban Renewal Committee reduced streets planned for urban renewal, introduced the system that imposed tram railway project costs on the electric railway company, and completed most of the tram network by 1910. In addition, the fact that the city street plan was expanded in 1912, along with tram network expansion, confirms that urban planning at that time had been changing the city in response to a new transport system.

5.1. Taipei (1895~1945)

Taiwan City Walls were built by traditional norms such as feng shui geomancy and Chinese Royal Records. Before Japan came to rule the city, downtown Taipei consisted of three areas: Monga, where a cluster of houses were formed in the 18th century, Dadaocheng, established in the 19th century, and the inside of the city walls whose construction began in 1879. The Qing dynasty, which was threatened by Japan's military advances in Taiwan, divided Taiwan Prefecture, which was the only prefecture established in Tainan, and created Taipei Prefecture. It built the administrative complex between the economically prospering Monga and Dadaocheng and constructed the walls to create Taipei City Walls. During Japanese colonial rule, Taipei faced the largest challenges of sanitation conditions in downtowns, including pests, and urban renewal was realized to improve the situation. Taipei's urban renewal mostly addressed the inside of the city walls and primarily designed water and sewage works. The planned street network was based on the extension or standardization of existing streets. In Monga and Dadaocheng, existing roads were used as much as possible for renewal (Figure 5).

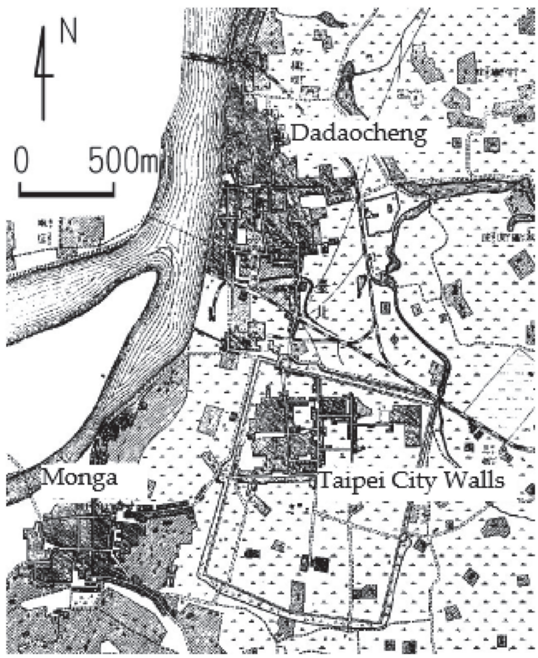


Figure 5. Map of the traditional city of Taipei in 1895 (1985, land survey).

With the opening of the Keelung-Hsinchu railway, Taipei Station was built in 1891. Taipei Station was located north of the city walls and south of Dadaocheng. The railway line ran from the west of the city walls through Monga in 1901. Taipei's urban planning focused on sewage works in the first and second urban renewal plans and planned the city walls and south and east areas outside the city walls in the third and fourth plans. It was in 1905 that the city planned to connect the inside of the city walls, Dadaocheng, and Monga. Then, the Great Taipei Urbanization Plan aimed at connecting the inside of the city walls as well as traditional housing clusters in Dadaocheng and Monga, and expanding the city walls eastwards.

5.2. Seoul (1910~1945)

Hanyang (Seoul), which was designated as a capital of Joseon, was established using traditional urban planning ideas of Feng Shui geomancy, China's city wall planning norm Chinese Royal Records, and considering the natural environment, including the original topography and terrain. Feng Shui geomancy had a significant effect on the decision to select Hanyang as a capital and the location of Gyeongbokgung, the royal palace. Around the palace, the locations of other major buildings such as shrines, ritual sites, and government offices followed the principles of ‘shrines on the left, ritual sites on the right, government offices on the front, and markets on the back’ in Chinese Royal Records. The palace was not located in the middle but north, and market stores were built in front of the palace. The modernization of Joseon’s capital Seoul began after the opening of ports in 1876. Since he took royal refuge at the Russian legation in 1896, King Gojong had implemented the Urban Rebuilding Project around Gyeongun-gung during the Korean Empire (Figure 6).

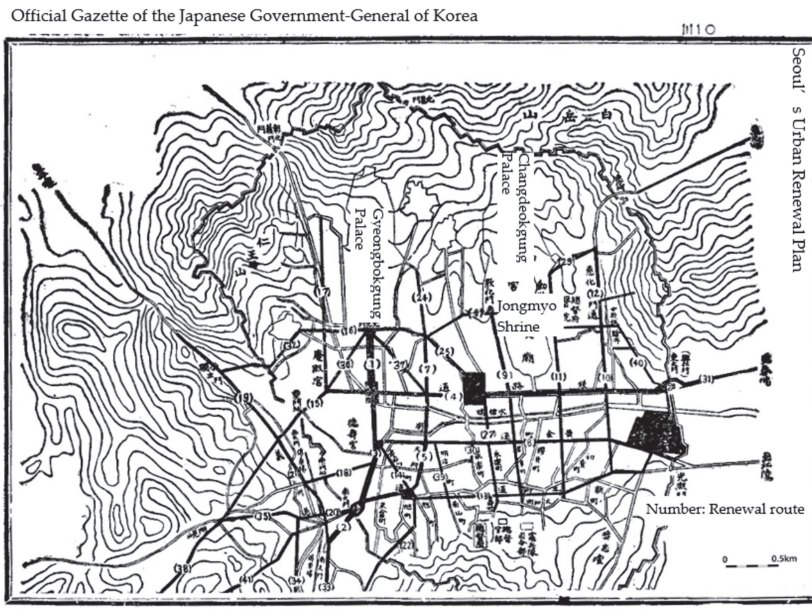


Figure 6. Map of Seoul’s Urban Renewal (Government-General of Joseon Gazette, Notice No. 173 in June 1919).

After Japan won the Russo–Japanese War in 1904 and signed the Eulsa Treaty, the effective power of the Korean Empire was transferred to the Resident-General. From 1907, the Resident-General began to reshape spaces in Seoul. With Gyeongseong Prefecture Urban Renewal during the Resident-General period, Seoul’s urban renewal established a straight road connecting Donhwamun, Gwanghwamun, Daehanmun, and Namdaemun, which ran through Gyeongbokgung, a visual focus in the spatial structure of fortress walls, and Gyeongun-gung, which emerged as a new visual focus with the Urban Rebuilding Project during the Korean Empire period [34]. Afterwards, the 1912 urban renewal plan, implemented by the Government-General, focused on turning Seoul’s urban organization into a grid shape. When it came to the responsible organization and funding, the Gyeongseong Civil Works Office implemented urban renewal, directly under the Department of Civil Works of the Regional Bureau of the Government-General, and then transferred to Gyeongseong Prefecture. For funding, until the urban renewal plan was announced in 1912, road paving funds from the Government-General were used, but afterwards, funds were secured by selling government properties.

Japan established urban planning in 1919, which affected Seoul, and discussions on urban planning were held in the city as well. The most central figure was Inspector-General Mizuno Rentarō of Political Affairs, who was elected in August 1919 along with Governor-General Saitō. Mizuno had a deep personal relationship with Gotō Shinpei and served as a director in the Imperial City Redevelopment Institute after the Great Kantō earthquake. During this period, the Gyeongseong Urban Planning Research Association was organized, and the draft of Seoul urban renewal plan was completed in 1925 but did not include benefit principles. In the fortress walls of Seoul, sections connecting the Japanese Army Garrison in Yongsan were rebuilt, and as a result, the downtown tended to expand towards Yongsan (Figure 7).

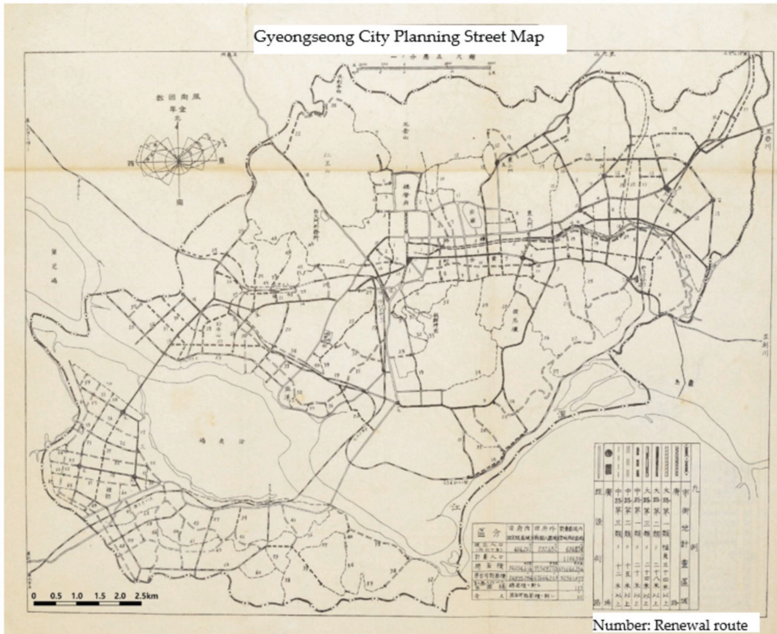


Figure 7. Seoul Downtown Planned Street Network Map.

In Seoul, the tram railway was built in 1898. Urban renewal implemented since Japanese colonial rule was planned to sort out roads in line with the tram network. Like Tokyo, modern urban planning was established with the construction of major transport facilities in mind, as transport convenience was one of the most important pillars in the city.

5.3. Beijing (1936~1945)

Beijing served as a capital as in 'zhongdu (central capital)' for the Jin dynasty (1115–1234) and 'dadu (big capital)' for the Yuan dynasty (1271–1368). Beijing was built under the principles of castle planning in Chinese Royal Records. With the emperor's residence at the center, fields, additional palaces, roads, streams, and bridges were connected organically across the entire Beijing (Zhu, 2006). After the Qing dynasty's feudal monarchy crumbled due to the Xinhai Revolution, urban renewal and construction began in Beijing.

The Beiyang government (1912–1928) created the Capital Urban Renewal Office, which took charge of urban planning and construction in Beijing, and turned facilities related to the emperor in the Qing dynasty into public spaces. In addition, streets, gates, and walls were renovated to allow for vehicle traffic. With the Manchurian Incident in 1931, Japan occupied Northeast China and took over Beiping in 1937 (its name was changed to Beijing in April 1938). In December 1937, Japan established the Provisional Government of the Republic of China in Beijing and the North China Political Affairs Commission in March 1940. At that time, Beijing functioned as a capital for the regime in North China and played an important role to allow Japan to form a colonial stronghold. The population grew fast after Japan took over Beijing, and there were growing needs for urban planning in response to the population growth. In Beijing, the area in which the city walls used to be was designated as the old city center, and new cities were built westwards instead of expanding the old city center (Figure 8).

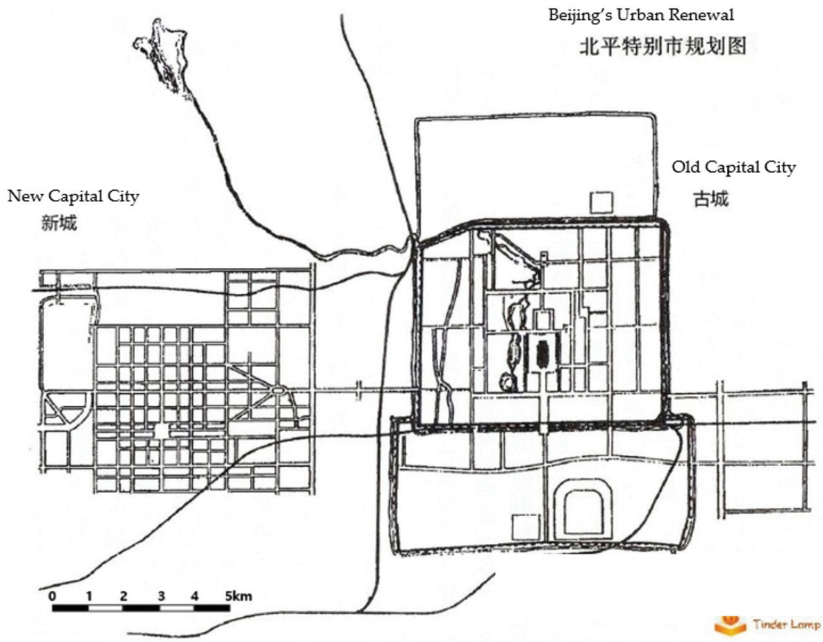


Figure 8. Map of for Beijing's Urban Renewal (Capital Library of China).

6. Conclusions

Tokyo started urban renewal quite early in 1876 to present itself as the modern capital of Japan. Plans and revisions for urban renewal were presented before establishing the Urban Renewal Plan in 1914. While the planning for urban renewal was discussed primarily for Tokyo, the implementation of urban renewal plans was carried out in a similar period also in other colonized cities. Tokyo enacted the City Planning Law for the first time in 1919 and revised it in 1933. The City Planning Law for each city under colonial rule was discussed and introduced based on it. In 1940, Seoul had a population of 940,000 people, Taipei 330,000, and Beijing 1.6 million, and along with urban scale problems, the timing of urban planning and the existence of the old city walls made a difference in each city's planning. What Tokyo, Seoul, Beijing, and Taipei had in common was that they were all centered on the existing city walls.

This study aimed to examine the conclusions drawn about modern city planning, its timing of implementation, and its effect in several cities. The study found that the establishment of organizations for decision-making and implementation preceded urban renewal projects in all cities.

Firstly, urban renewal projects and city planning laws were carried out in different cities. It mentions that each city established an organization for decision-making and implementation prior to urban renewal projects, and the timing of these organizations varied among the cities.

The sewerage networks were planned by experts in sewage planning, while other city planning was led by administrators. In the colonial cities of Taipei and Seoul, urban renewal was led by the Government-General, while in Tokyo and Beijing, the respective government agencies were responsible for urban planning. In Tokyo, the Tokyo Urban Renewal Review Committee was established in the Home Ministry in 1885, and the Tokyo Urban Renewal Committee was created in 1888. The City Planning Law Implementation Preparation

Committee was established by the Government-General of Taiwan in 1934. In Seoul, the Urban Planning Research Association was established in 1928, and the Kyungseong Urban Planning Survey Committee was organized in 1933. Japan took over Beijing in 1937 and the General Office of Construction was established in the North China Political Affairs Commission in 1938, with the City Bureau thereunder to push for urban planning. While the timing was different, the establishment of organizations to plan urban renewal and the city planning law went ahead in a similar pattern in colonized cities. With respect to planners, although an expert was invited to plan sewage works, urban planning for other works was carried out by administrators in the cities. The urban planning in Taipei and Seoul was led by the Resident-General or Governor-General appointed at that time.

Secondly, the implementation of urban renewal and the City Planning Ordinance among several cities was carried out in the following order: First, urban renewal was planned for Tokyo, but it was actually applied in Taipei before Tokyo. Taipei underwent urban renewal before other cities, and its street system was based on the grid-iron design. Meanwhile, the City Planning Ordinance was first planned and implemented in Tokyo and later spread to other colonized cities during a similar period.

Thirdly, the effects of urban renewal and the City Planning Ordinance in each city were similar in that they started by rebuilding the old city walls and then shifted their focus to expanding the city and suburban areas. Tokyo renovated Edo, which was a traditional city, through Urban Renewal Plan, and it was expanded to the west, south, and north of Edo through the City Planning Law. The Great Taipei Urbanization Plan aimed at connecting the inside of the city walls as well as traditional housing clusters in Dadaocheng and Monga and expanding the city walls eastwards. Seoul renovated the traditional city through Urban Renewal Plan, and the expansion of the new urban area tended to expand towards Yongsan and Yeongdeungpo area (southwest). In Beijing, the area in which the city walls used to be was designated as the old city center, and new cities were built westwards instead of expanding the traditional city (Figure 9).

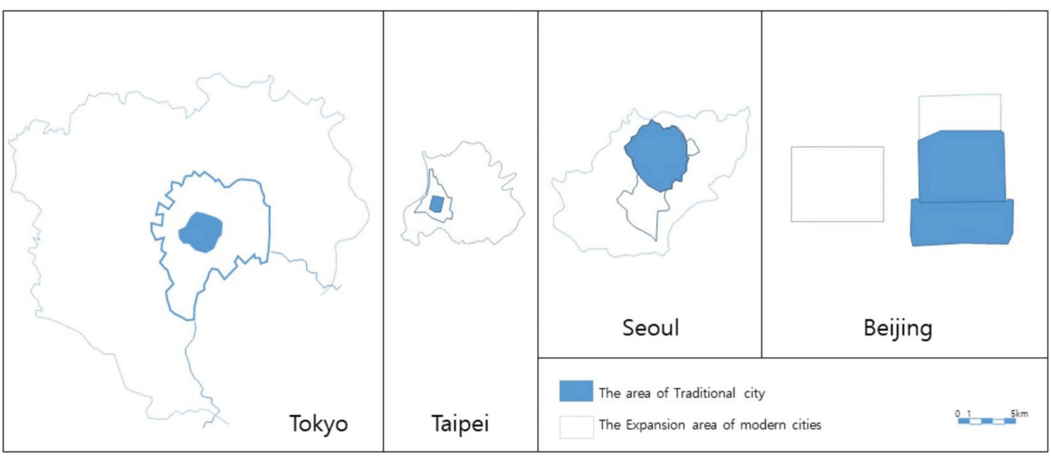


Figure 9. Changing shapes of traditional cities Edo, Taipei, Seoul, and Beijing.

Finally, the urban renewal project and City Planning Ordinance in each city had different characteristics: Taipei aimed to integrate sewage systems and streets and built a new downtown on top of the old one, which was destroyed by a natural disaster, with Japanese financial support. Tokyo aimed to integrate sewage systems and streets as well, but it did not happen as planned due to financial difficulties and disasters. Instead, it focused on rebuilding roads within the existing urban structure. Seoul's sewage works were developed independently of streets as a result of rebuilding small streams. The plan prioritized preserving the existing city, but due to funding constraints, it focused on rebuilding the existing downtown through land readjustment. It had a longer history of discussions and survey activities for urban planning due to a longer colonial rule. Beijing planned for new cities and placed greater emphasis on preserving the old city walls, leaving the urban structure unchanged. It relatively overlooked the old city walls.

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Article

Spatial Form and Conservation Strategy of Sishengci Historic District in Chengdu, China

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Abstract: The historic district is a carrier to show the urban landscape, and the analysis of the spatial form of the historic district from human behavioral activities is beneficial to grasp the social and functional attributes of the space. Combining with the spatial layout of the Sishengci historic district, the overall spatial structure of the Sishengci historic district is analyzed in terms of integration, connectivity, control, depth, and intelligibility by using the analysis of the axial lines in space syntax through the relationship diagram and quantitative description of the syntax. Based on the findings, targeted conservation strategies are proposed, namely the conservation of the core area of the district, the shaping of the local spirit, and the reconstruction of the social space, which have a guiding significance for the conservation and renewal of the Sishengci historic district.

Keywords: historic district; spatial morphology; space syntax; conservation strategy

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1. Introduction

The concept of historic districts first appeared in The Athens Charter. Buildings and districts of historical value shall be appropriately preserved and shall not be destroyed [1], distilling buildings and districts of historical value into a single category. The concept of historic districts was introduced in The Washington Charter, which defined them as cities, towns, historical centers, and residential areas, regardless of their size, and also their natural and manufactured environments [2]. The introduction of this concept extended the original concept of buildings and districts of historical value to include the environments in which they are located. Historic districts refer to areas where the architectural heritage is more concentrated or where the traditional style and local characteristics of a certain period are better reflected intact. However, with the accelerating urbanization, many cities with traditional historic districts are undergoing large-scale urban renewal. Although the physical environment of historic districts has been improved, the spatial form of historic districts has been severely damaged by massive demolition and construction [3]. Historic districts are still trapped in a situation of insufficient spatial group vitality, lack of spatial quality, and lack of regional culture. Many of them lack daily activities for residents to maintain vitality and meet the growing social needs [4]. Historic districts are facing the problem of balancing development and conservation [5]. In order to retain urban diversity and vitality, historic districts with diverse roles and appropriate scales must be preserved [6,7] but also for preserving traditional urban culture.

China State Council published the initial administrative document on urban planning in February 2016. The document highlights the need for orderly urban restoration and organic renewal, addressing issues with environmental quality degradation, spatial disorder, and the destruction of historical and cultural heritage in old cities, restoring the functions and vitality of old cities, better preserving the historical heritage, and presenting the urban landscape [8]. The historic quarter is, without a doubt, the source of the city's life. The historic district keeps the artifacts' vibrant real-life history and true historical knowledge intact. It has a certain size that may accurately capture the special qualities of a particular historical era, a particular nationality, or a particular location. It serves as a vehicle for preserving the city's historical culture and displaying the urban environment. In the environment of urban renewal, it is inevitable to explore and analyze its spatial form to find a targeted conservation strategy. The urban form depends on the interaction between people and urban public space, and the intertwined processes of people's activities and places of residence make urban life more diverse and dynamic [6,9]. The Venice Charter promotes the original conservation of the historic spatial environment [10]. Urban space can be defined as a perception revealed by the urban fabric [11–13], a social and cultural phenomenon that shapes the relationship between people and the environment [14]. This scene forms a way of daily life, capable of meeting people's needs [15]. In particular, street networks are a long-term component of the urban form [16–19] and are an essential driver in the urbanization process [20], with street layout identified as a significant factor influencing pedestrian movement in cities [21–24]. Data-based urban morphology attempts to model spatial data to track urban morphology, spatial order, configuration, and orientation, and one approach is the space syntax.

Understanding urban space in its physical, morphological, and social components is made possible by the space syntax [25–27], providing a different approach that focuses on topological aspects of urban morphology to estimate the supportiveness of the built environment. The space syntax initially focused on city pedestrian movement [22,28]; however, further research discovered a strong correlation between topological measures and social engagement [29–31]. This circumstance can clarify the connection between spatial shape and human behavior in the environment [27]. The Sishengci historic district has a long history, and it is crucial to study the spatial form of the historic district to conserve the spatial form of architectural heritage. In order to solve the problem of social integration of the residents in the historic district and to maintain the sustainable organic vitality of the district, this study is a methodological exploration of conservation and renewal in the Sishengci historic district, uses the space syntax of the axial lines analysis method, discusses the analysis of the historic district and its development law from a rational point of view, quantifies the interpretation of the spatial form of the historic district, and proposes the strategy of conservation and renewal of the historic district here to meet the social integration of the residents.

2. Methodology

2.1. Research Area

The Sishengci historic district is located in Jinjiang District, Chengdu, China (Figure 1), and the district extends from Xinhua Boulevard and Yuefu Street in the north, to Shudu Avenue in the south, to Taisheng South Road and Hongxing Road in the west, and to Dongan North Road and Dongan South Road in the east (Figure 2). The Sishengci historic district is strategically located, with a deep historical and cultural heritage and many indigenous inhabitants. As a Chinese historical and cultural district, it still preserves the intact architectural style of the Republic of China era. The existing buildings are mainly western-style buildings and residential buildings with western Sichuan structures.

The Sishengci historic district basically follows the road structure of the traditional streets and alleys of Chengdu, forming a complete urban node as early as the Republic of China era. After going through the round-trip process of reconstruction, destruction, and reconstruction again in different eras, the district's buildings have also survived the construction characteristics of each period.

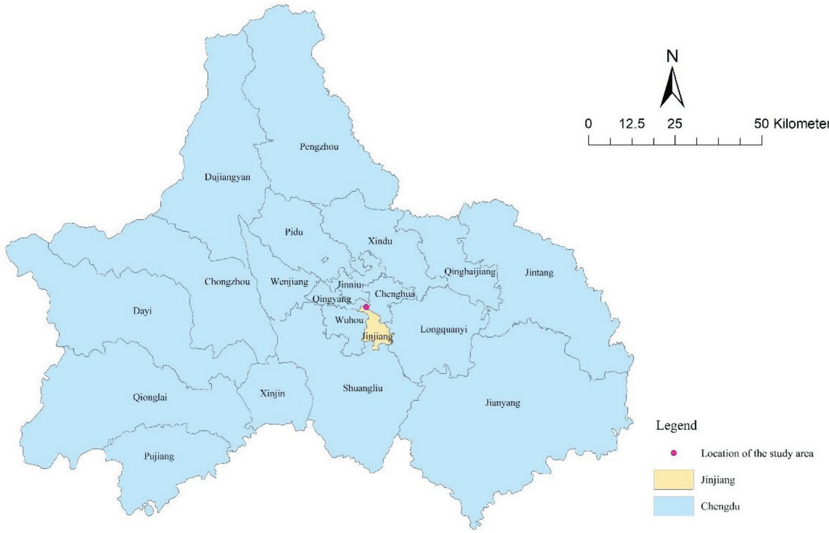

Figure 1. Location of the Sishengci historic district.

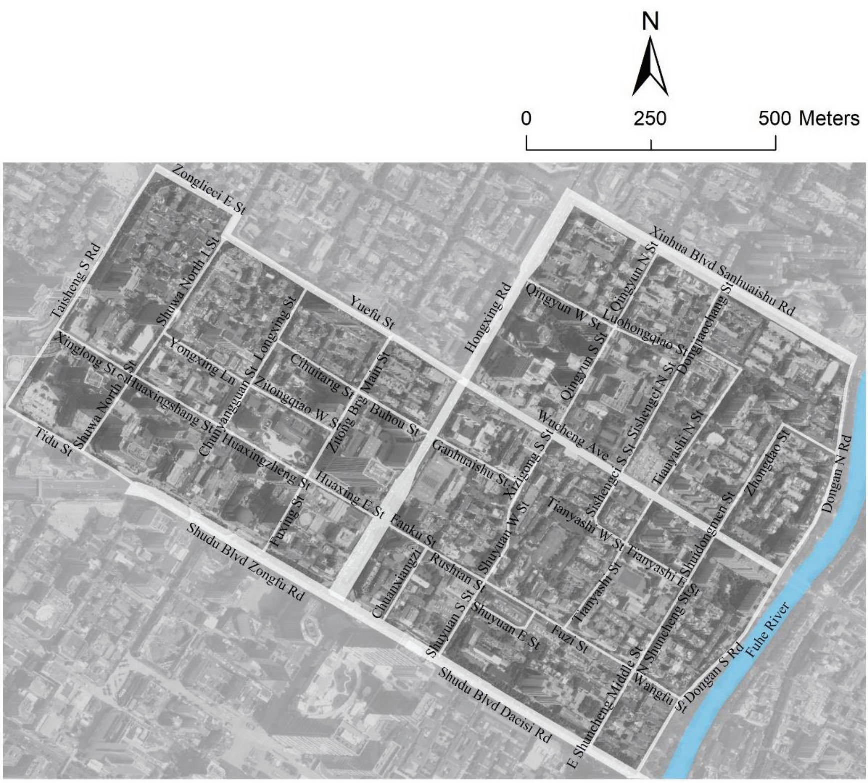

Figure 2. Sishengci historic district scope map.

2.2. Space Syntax and Syntactic Variables

Human perception of spatial systems is always dependent on small-scale space, and the integration of local information creates an understanding of the whole, according to the perspective of spatial perception. Therefore, understanding large-scale space begins with comprehending small-scale space. In spatial studies based on space syntax, it is presumable that the street network divides the large-scale urban spatial system into multiple identifiable small-scale core components. Axial lines analysis is the dividing technique that is most frequently employed. The dividing method that is most frequently used is axial lines analysis. In this study, we choose axial lines analysis, where the generated morphological variables are used by space syntax to quantitatively characterize the space, and axial maps are used to examine the spatial morphological structure [27]. The following section lists the main morphological variables.

2.2.1. Connectivity

The number of spaces in the system that are connected to space i is indicated by the connectivity value [32]. In the map of the axial lines, transportation networks are abstracted as interconnected axial lines, which correlate spatial systems. The more an axial line is connected to other axial lines, the better the spatial accessibility and the higher the value of connectivity, as shown in the formula:

$$Con_i = k \tag{1}$$

where k is the number of spaces that are connected to space i, $i = 1, 2, 3, \ldots, n$; n is the total number of spaces in the system; Con_i is the connectivity value of space i.

2.2.2. Control

The control value refers to the relative degree of control of space i over the spaces intersecting it [27], and the control value reveals the relationship between adjacent spaces in the system, as shown in the formula:

$$Ctrl_i = \sum_{j=1}^{k} \frac{1}{Con_j} \tag{2}$$

where $Ctrl_i$ is the control value of space i, space j is the space connected with space i, and Con_j is the connectivity value of space j, $j = 1, 2, 3, \ldots, k$.

2.2.3. Depth

Depth is the minimum number of spaces traveled to reach a destination [27] and expresses the accessibility of the axial nodes in the system in a topological sense. The sum of the depths of each other space in the system determines a space's overall depth. The mean depth, which is the average distance from space i to all other spaces, reflects how simple it is to access the designed space in the system [27]. This is an essential measure of the accessibility of an area, as shown in the formula:

$$MD_i = \frac{TD_i}{n-1} = \frac{\sum_{j=1}^{n} d_{ij}}{n-1} \tag{3}$$

where d_{ij} is the shortest distance between space i to space j, TD_i denotes the total depth value of space i, and MD_i is the mean depth value of space i.

2.2.4. Integration

Integration shows how space i is connected to other spaces and their surroundings, considering the earliest lines and the systematic distances between all points of the system [33] and real relative asymmetry (RRA) is the opposite of integration. RRA eliminates the effects of the spatial structure itself and the spatial structure based on the mean depth. The formula is as follows:

$$RRA_i = \frac{2(MD_i - 1)}{(n-2) \times D_n} \tag{4}$$

$$D_n = \frac{2\left\{n\left[\log_2\left(\frac{(n+2)}{3}\right) - 1\right] + 1\right\}}{(n-1) \times (n-2)} \tag{5}$$

where D_n represents the integration measure's standardized value and RRA_i denotes the RRA value of space i.

3. Results

Firstly, the basic information about the Sishengci historic district was collected, and the axial lines map of the Sishengci historic district was drawn through the space with the longest and least axial lines according to the relationship between the streets. DepthmapX was used to calculate the axial lines, quantify the relationship between each street space, and analyze them with the field survey. When the axial lines are analyzed, each has different colors and represents different parameter values. Warm colors represent larger parameter values, and cool colors represent smaller parameter values, and the darker the warm color is, the larger the parameter value it represents. The darker the cool color is, the smaller the parameter value it represents.

3.1. Integration Analysis

Global integration describes how closely a space is connected with all other spaces. The part of axial lines with higher integration in the axial lines system is often the spatial core, whose spatial accessibility and publicness degree is higher and plays an essential role in the district. Analyzing the global integration map (Figure 3) shows that its spatial core position is relatively apparent, and the red axial lines with high integration constitute the spatial core of the Sishengci historic district. In this case, it refers to the axial lines with the highest integration, namely the axial lines formed by Xinglong Street, Huaxingshang Street, Huaxingzheng Street, Huaxing East Street, Fanku Street, Rushian Street, Fuzi Street, and Wangfu Street, which shows a highlighted red color. It passes through the whole Sishengci historic district in the form of a straight line.

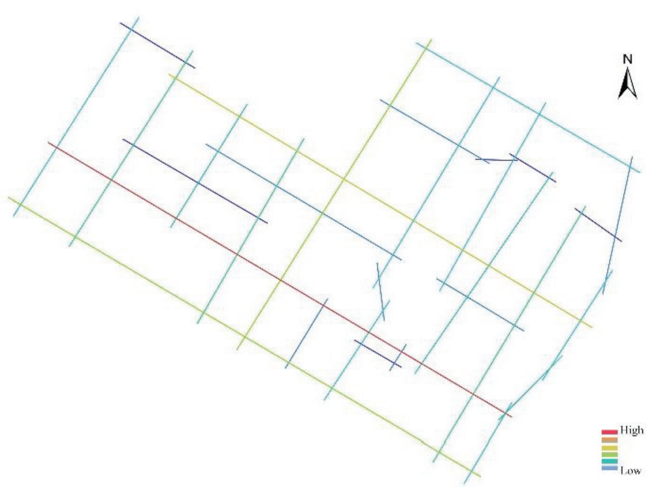

Figure 3. Global integration map.

This axial line is located on one of the longer horizontal roads in the neighborhood and has high accessibility. These streets are the most accessible and convenient places in the district, where traffic and pedestrian flow are most frequent, and are also critical public spaces. The form of this space still maintains the original traditional form, and this axial line is adjacent to the Jinjiang Theater, Wangfujing Shopping Mall, and other public activity spaces, which is a relatively dense public space.

The Sishengci historic district is crisscrossed with streets and alleys and has many historical relics of cultural protection units. The Sishengci historic district has a high integration of axial lines concentrated throughout, with a prominent center of the district and a very convenient core space for transportation. It continues the spatial structure of the traditional district and is a living place suitable for human-spatial relations, social functions, and spatial relations. The short axial lines located near the Fuhe River and inside the district are less integrated, and the district has more residential buildings. However, some of its spaces are relatively less accessible because they are located relatively deeper in the road. In conclusion, the Sishengci historic district has apparent spatial integration with significant core spaces, while some spaces are less integrated due to the distribution of roads and their locations.

3.2. Connectivity Analysis

The connectivity indicates the number of axial lines directly connected to an axial line. The higher the spatial connectivity, the higher the breadth of visual penetration. The connectivity value map (Figure 4) shows that the connectivity value of the axial lines connecting Xinglong Street, Huaxingshang Street, Huaxingzheng Street, Huaxing East Street, Fanku Street, Rushian Street, Fuzi Street, and Wangfu Street is very high at 12. This axial line is very regular and points to the center of the district, indicating that the road in the center of the district has strong permeability and takes on a crucial traffic function. Among them, Huaxing Street is the most prosperous section of the whole area of commerce and trade. Sichuan Daily Newspaper Press Group, Hampton By Hilton, and Western Culture Industry Center are in this area. The connectivity value of the axial line connecting Yuefu Street and Wucheng Avenue is also high, with a connectivity value of 9, and their directions are consistent with the center of the district. The axial line connectivity value at Hongxing Road is 6, closer to the center of the district and connects the school and transportation stations with the center of the district. In general, the Sishengci historic district extends in two directions, northeast–southwest and northwest–southeast, regardless of the direction of the roads or rivers. The development trend of its historical urban space is basically along this direction. Axial lines with low connectivity values are scattered within the district, which is related to the fact that the roads are irregularly connected, causing obstruction to the sight lines and affecting the connectivity values.

3.3. Control Analysis

The Sishengci historic district is the earliest cluster of Western-style buildings in Sichuan, China, with a full range of types, including churches, hospitals, schools, and residential houses. The analysis was conducted from the control values and indicates the degree of influence of space on its adjacent spaces; higher values indicate that it is easier to reach. In the control value map (Figure 5), it can be seen that the axial lines formed by Xinglong Street, Huaxingshang Street, Huaxingzheng Street, Huaxing East Street, Fanku Street, Rushian Street, Fuzi Street, and Wangfu Street have the highest control value, which is importantly related to the fact that the roads on the axial lines are connected to many streets in the district. This shows the high control of the central space of the district in the Sishengci historic district. The high intensity of control of the center of the neighborhood over the surrounding spaces adjacent to it indicates that it occupies a certain position in the district and has a strong influence, and the space extending along this direction can become a field for the future spatial development of the historic district. The short axial lines in the district have low control values, indicating that these axial line spaces do not have a high degree of mutual control with each other.

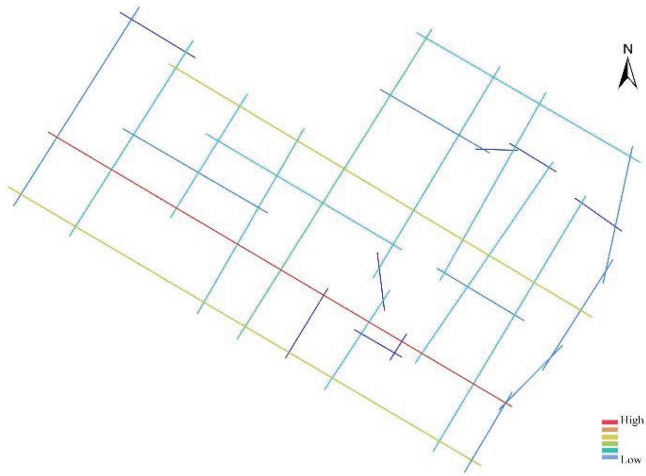

Figure 4. Connectivity value map.

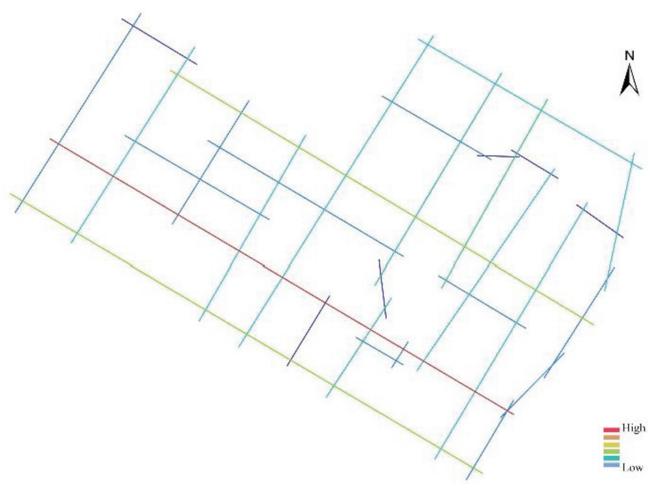

Figure 5. Control value map.

3.4. Depth Analysis

The streets in the Sishengci historic district are narrow. They are used for social interaction on foot or by bicycle, so the streets are public spaces for people to carry out their activities. The analysis is carried out from the depth value, which indicates the minimum number of spatial transitions required to reach other spaces in a system. The higher the depth value, the less accessible the space is, and the lower the intensity of human activities in this space. In the depth value map (Figure 6), the axial lines with lower depth values are mainly located in the center of the district, Xinglong Street, Huaxingshang Street, Huaxingzheng Street, Huaxing East Street, Fanku Street, Rushian Street, Fuzi Street, and Wangfu Street, which are road spaces with higher accessibility. This axial line divides the district, and this road division pattern helps to disperse people's flow, which is in line with the development law of the human living environment. The axial lines with higher depth values are concentrated and distributed in the same area as the overall higher integration range, indicating that these spaces of Xinglong Street, Huaxingshang Street, Huaxingzheng Street, Huaxing East Street, Fanku Street, Rushian Street, Fuzhi Street, and Wangfu Street are closely connected to the center of the district and easily accessible.

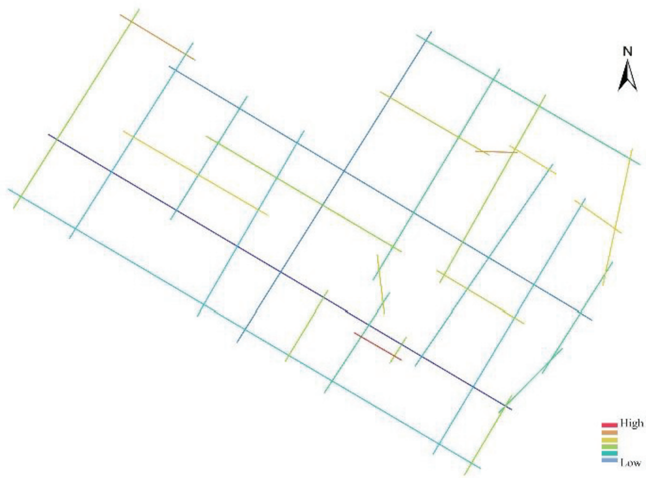

Figure 6. Depth value map.

3.5. Intelligibility Analysis

Sishengci historic district is the starting point of Western medicine in Sichuan, the origin of modern medicine in Sichuan, and once made a significant contribution to the life and health of the Sichuan people. In terms of intelligibility analysis, intelligibility is a variable that represents the relationship between connectivity and global integration, and its value is expressed by the linear regression coefficient R^2 between these two types of variables. Intelligibility is used to represent and index the readability of the overall space based on the local space. It means the amount of connected space seen from space can be a helpful guide to integrating the space that we cannot see. It can be used to measure whether the local spatial structure seen contributes to the understanding of the overall spatial system. An unintelligible environment can be interpreted as a rupture of this cognitive and grouping relationship. In the intelligibility analysis, the connectivity was selected for linear regression analysis with the global integration, and the intelligibility of the axial lines system was derived from the XY scatter plot (Figure 7) to quantify the spatial relationship between the historic district locally and as a whole. In the figure, X denotes global integration, Y denotes connectivity, and R^2 denotes intelligibility. The red dots at the top right indicate the axial lines with higher intelligibility, while the blue dots at the bottom left indicate axial lines with lower intelligibility.

The scatterplot shows that the axial lines represented by the red dots with high intelligibility are formed by the connection of Xinglong Street, Huaxingshang Street, Huaxingzheng Street, Huaxing East Street, Fanku Street, Rushian Street, Fuzi Street, and Wangfu Street. These axial lines are surrounded by critical public spaces, in line with the axial lines in the center of the district. They occupy an important position in the district and are iconic. The intelligibility value of the Sishengci historic district is about 0.86, which is high. It shows that it is easier to perceive the overall spatial system of the historic district from the local space, the recognition of the streets is high, and its street space presents a regular form. During the development process of the historic district, attention should be paid to the conservation of the texture and natural form of the historic district.

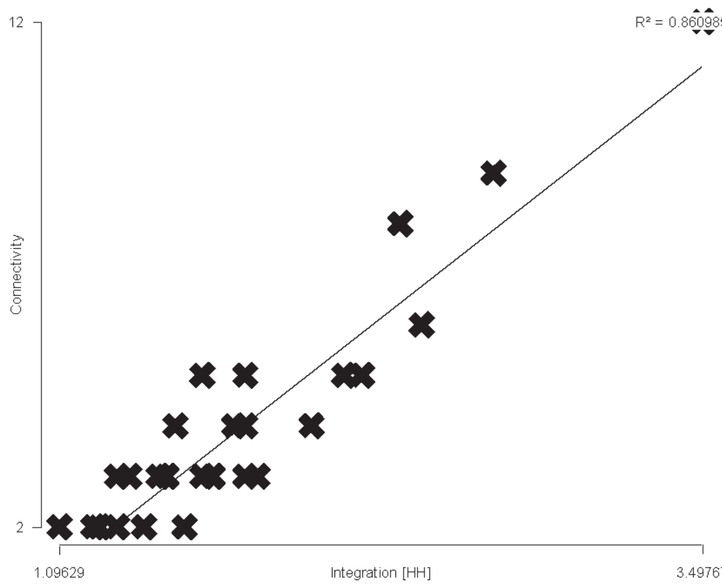

Figure 7. Intelligibility scatterplot.

4. Conservation Strategies for the Sishengci Historic District

As a carrier of urban heritage, the systematic conservation, utilization, and inheritance of historical and cultural heritage in urban construction are of great significance to the continuation of the city's history and culture and the promotion of urban development. When carrying out district conservation, it is possible to refer to the syntactic model data to understand the district characteristics. Here, the example of the Sishengci historic district in Chengdu is used as a reference for the conservation of historic districts.

(1) Conservation of the core area of the district. A long-term practice called conservation works to prevent harm to a building's or area's unique character. It is a deliberate process that, over time, maintains little change. According to The Burra Charter, conservation refers to all actions taken to safeguard a location in order to maintain its cultural relevance [34]. The term "conservation" encompasses all aspects of preservation together with interventions of every sort, including restructuring, revitalization, restoration, and regeneration. The historic district has a long history and preserves a splendid architectural heritage. The core of these historic districts' overall space is Xinglong Street, Huaxingshang Street, Huaxingzheng Street, Huaxing East Street, Fanku Street, Rushian Street, Fuzi Street, and Wangfu Street, which is the crucial object of the district's protection. Chengdu, as a historical city, has carried out region-wide tourism in recent years, which has caused a certain impact on the conservation of historic districts. According to the spatial axial lines analysis, the complete preservation of the local and overall core areas should be firmly ensured so their spatial forms are not destroyed, and the core influence of the cultural sources is brought into play. Under the premise of conservation, the tourist flow should be adequately controlled to avoid destroying the protected area space and architecture.

(2) Emphasis on street space interaction function. People exist in local social life practices, and their daily settlement behavior constantly repeats their experience of place and strengthens their interaction with it, making it a key element in the construction of self-identity and reflecting the strong connection between people and place. As a result, history is not only fixed in the buildings of the historic district, but also penetrates into the lives, work, and social networks of the residents. The conservation of historic districts should also focus on promoting community management, activities, and cultural promotion. The core concept of conservation also lies in promoting sustainable social development through

economic and cultural recovery and other diversified means. Therefore, it is important to pay attention to the participation of residents in the conservation of historic districts and inform them in time to enhance their sense of participation. The street space in the historic district is mainly a space where people's behavioral activities are frequent and communication is high, so it is possible to set up benches, landscape vignettes, and other resting service facilities according to the current situation to increase the time of people staying in the space and play the interaction function of the street space. By continuing the existing social networks and daily life experiences, the conservation of the Sishengci historic district integrates the residents into the social space of the district and preserves the spatial connections between the residents and the original social attributes of the Sishengci historic district. By creating multi-level tourism routes, visitors can learn about the actual residents' living conditions and have a richer viewing experience while traveling. As a common memory of urban residents' life, the historic district space is a valuable resource for future development and can inject new vitality into the city [35,36].

(3) Extraction of the cultural genes of the historic district. The public space of the historic district has the functions of worship, assembly, life, and transportation, closely related to the life of residents and the activities of visitors, and is a valuable material cultural heritage of the historic district, as well as a carrier of immaterial culture. As imagery of material culture and living environment, the Sishengci historic district can be regarded as a container of time. Once the past time is attached to the long-established heritage, it is bound to penetrate into countless fragmented individual experiences and is constantly reshaped by recollection or forgetfulness, taking on a variety of complex forms, not so much as real history, but as constructed memory [37]. Therefore, in the conservation process, in addition to adhering to the basis of authenticity and cultural living preservation, we must also fully understand the spatial characteristics of the heritage resources in the historic district, refine the cultural genes of the ancient town, and excavate the deep cultural structure. By making architectural places and cultural symbols of historical relics into cultural carriers, shaping local characteristics and creating memories of places, triggering pride and identity of residents in their way of life, and promoting positive human experiences in historic districts, they become a set of readable symbols and messages that become an environment that expresses itself [38]. The future can be based on this to attract socio-economic investment and implement industrial operations through cultural heritage and innovation.

5. Discussion

In recent years, research has begun to focus on historic districts in cities, and quantitative studies can accurately determine the problems in the spatial development process of the districts and remedy the current situation that heritage planning projects ignore the relationship between the local and the whole. Koohsari used the historic district of Taiping Street in Changsha, China, as an example, compared the cognitive map and the syntactic model, and found that the syntactic model and the cognitive map's nodes had a strong correlation, as well as the road networks [39]. Using axial and image maps, Yu and Liu investigated a specific variation of Gulangyu Island in Xiamen, China [40]. Kubat investigated pedestrian and vehicular activities in Sharjah historic center in the United Arab Emirates (UAE) to comprehend the existing movement patterns and examine the physical structure [41]. Wang and Bramwell compared historical urban districts in China using a space syntax [42]. Previous research results have focused on comparing and analyzing the relationship between space syntax and cognition to provide a basis for the design process. In this study, we use the integration, connectivity, control value, depth value, and intelligibility of space syntax theory to dissect the spatial cognition of the Sishengci historic district, not only to analyze the spatial structure but also to propose the conservation strategy of the historic district as a result, which provides a new perspective for the study of strategic conservation of the historic district.

In this study, some insights can be drawn from the case of the Sishengci historic district in the conservation and development of historic districts. Quantitative analysis should be integrated into the whole dynamic process of district conservation and development. The conservation of historic districts is a dynamic process. Urban problems will arise if the focus is only on the material heritage, such as historic buildings and historical relics, ignoring the social logic of space formation. It is necessary to comprehensively balance various factors, such as people's life, historical carriers, and newly implanted functions, and quantitative analysis and simulation integrated into the process of district conservation can maximize the conservation of the spatial structure and material carriers of historic districts. For example, in the stage of historic district conservation planning, quantitative analysis by space syntax is used to investigate, analyze the spatial structure of the district, and delineate the core conservation area of the district, which can maximize the conservation of the physical environment and social structure of the district.

6. Conclusions

Conservation of the historic districts' space is an important way for cities to inherit history and continue their cultural lineage. The formation of the historic district is influenced by various factors, such as natural conditions and social development, and its spatial form has shown its inherent development law in the development process. This study analyzes the space of the Sishengci historic district based on the space syntax, aiming to study the spatial form of the conservation and development strategy of the Sishengci historic district from a new perspective. The overall space and street space of the historic district are interpreted through the space syntax, analyzed in terms of integration, connectivity, control value, depth value, and intelligibility, and the conservation strategies are proposed in a targeted manner: emphasizing the focus on conserving the core area in the whole, refining the cultural genes of the historic district in the spirit, and emphasizing the street space interaction function in the social attributes, all of which have a guiding significance for the conservation and renewal of the space of the Sishengci historic district.

The analysis of the morphology of the historic district through the space syntax and the exploration of targeted development strategies are conducive to the inheritance of historical culture, regional characteristics, and the development of spatial morphology. At the same time, it is also conducive to the conservation and continuation of the spatial configuration of the historic district from a long-term perspective and the systematic conservation and development from a sustainable development perspective. Historic districts rich in cultural connotation and place memory not only promote the creation of urban image and cultural value but also satisfy people's pursuit of culture and spiritual enjoyment in the future, which has important strategic significance for the development of historic district space in Chengdu.

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The Decorative Auspicious Elements of Traditional Bai Architecture in Shaxi Ancient Town, China

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Abstract: The lucky cultural characteristics of traditional architecture are of importance. It shows what makes a place unique and the spiritual and material goals people have there. It is thus vital to understand the lucky cultural characteristics of traditional villages. This paper attempts to explore the auspicious cultural attributes of the town. We are aiming to reveal the current status of cultural integration in Shaxi's ancient town so that we can find the problems arising from the development process. Moreover, the research subject is the lucky element of Shaxi Bai's traditional architecture. Lucky themes include lotuses, unicorns, phoenixes, etc. The research was qualitative and quantitative, so we begin by identifying the lucky elements. Then, we used methods for analysing diversity and complex networks to determine their diversity indices and network model indicators. These findings show the old town's diversified, lucky culture. However, Buddhist culture dominates the multicultural makeup. Furthermore, the native Bai culture is also conserved and preserved.

Keywords: lucky element diversity; lucky cultural characteristics; co-occurrence network; Shaxi ancient town; Bai traditional architecture; multicultural integration; indigenous culture

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1. Introduction

Shaxi Ancient Town is situated in the Dali area of China, where the Bai people live. Today, it is the only typically well-preserved settlement. It combines Confucianism, Buddhism, and the commercial horse band culture. The early Ming and Qing architectural culture also influences the old town. It reflects the multicultural makeup of traditional Bai architecture. The ancient town of Shaxi has been home to one of the world's endangered buildings since 2002. Due to its modest village design and historical and cultural importance, Shaxi has become a renowned tourist attraction and social centre. Moreover, it has attracted tourists and researchers from all over the world. The Shaxi revitalisation project [1] has preserved the historic town in various ways. However, tourism and urbanisation have brought foreign cultures into the town. Many researchers are trying to explore this issue from different perspectives, as it is vital to find a new way to protect and bring life back to the traditional villages, such as cultural heritage [2], cultural tourism [3,4], and national culture [5]. Luck expresses the people's view of a brighter future. Different lucky cultures may reflect various folklore and cultural backgrounds. Common lucky elements include objects, behaviours, language, words, and numbers. Traditional architecture's lucky elements refer to the decorative motif in each building component. They also represent a desire for a better life. This study analyses the blessed cultural characteristics of traditional Shaxi Bai architecture.

Today, traditional village studies focus on cultural perspectives [6]. Ao [7] talked about how influential culture is. Moreover, America [8] explained how culture and architecture are linked. Xia [9] also said that local culture should be a part of historic districts. In the past few years, regions with distinct ethnic traditions have been the focus of Chinese architecture research, such as the southern part of Fujian [10,11], the northern part of Shaanxi [12], and Jinzhong [13]. Only some studies about the Bai region in northwest Yunnan are helpful. Aside from that, many studies on lucky culture focus on traditional residential architecture. Furthermore, most researchers have examined what architectural decorations mean to different cultures. Similarly to Xuan Ran [14], he looked at the artistic and cultural values already there. Wang Yan [15] demonstrated the significance of decoration in contemporary architectural design. Du Y [16] emphasised how the method of lucky decorations could be applied in practice. It integrates traditional architectural components such as random decorations into modern building design. Furthermore, this helps the Chinese architectural market change and preserves fortunate culture. Hongyan Xiang [17] demonstrates lucky culture through traditional building decorations, which are auspicious. It examined how traditional architecture preserves and promotes good luck. In conclusion, most research describes random things qualitatively, focusing on identification and appraisal. Few quantitative research has examined lucky element diversity and co-occurrence network properties.

We need qualitative and quantitative methods to reveal traditional architecture's lucky cultural traits. This study focuses on Shaxi, an old town in the Bai region of Yunnan Province. The first step was to carry out field research to find lucky elements. Then, we figured out the diversity index of lucky elements by diversity analysis. Moreover, we worked out the co-occurrence network index by complex network analysis. The last step is to compare and examine the calculations. This will reveal the lucky cultural characteristics of the classic old-town architecture. Next, the multicultural-indigenous culture link in the ancient town is investigated. In the historic town, to exhibit the cultural perspective of the Bai people, Shaxi may be an example of conserving and developing other traditional villages.

2. Overview of the Study Area and Research Methods

2.1. Overview of the Study Area

Shaxi Ancient Town is situated in Dali, Yunnan Province, China (See Figure 1). In 2001, the WMF (World Monuments Foundation) identified Shaxi as "the only ancient market on the Tea Horse Trail that still survives". In 2002, it was included on the World Endangered Architectural Heritage List [18]. It is incorporated as "a Yunnan province famous historical and cultural town", "a nationally famous historical and cultural city", "a famous tourist town in Yunnan", "108 Chinese village business cards", and "the village directory of Chinese rural cultural heritage monuments". This study is based on the "Historic Town Plan of Shaxi" from 2005. The plan shows where the old town reserve is. The region of protection (36.11° 11–26.19° N, 99.45°–99.58° E) has an area of 8.4 hm^2. Moreover, it is situated in the North Temperate Cool Layer at an average height of 2100 m. It has an average annual temperature of 12.3 °C, yearly sunshine hours of 2400 h, and annual precipitation of 790 mm [19]. The protected area centres on Xingjiao Temple, Sifang Street, and Ancient Theatre. South and North Guzong Lane are next to it, and traditional buildings are around it [20]. The share of conventional architecture is also relatively high. The population comprises Han, Bai, Yi, Lisu, Naxi, and other ethnic groups [21]. Bai accounts for 85 per cent of the entire population and is the largest ethnic group [22]. Bai is the fifteenth most significant ethnic minority in China. Thus, this region's traditional Bai architecture represents ancient Shaxi's lucky culture.

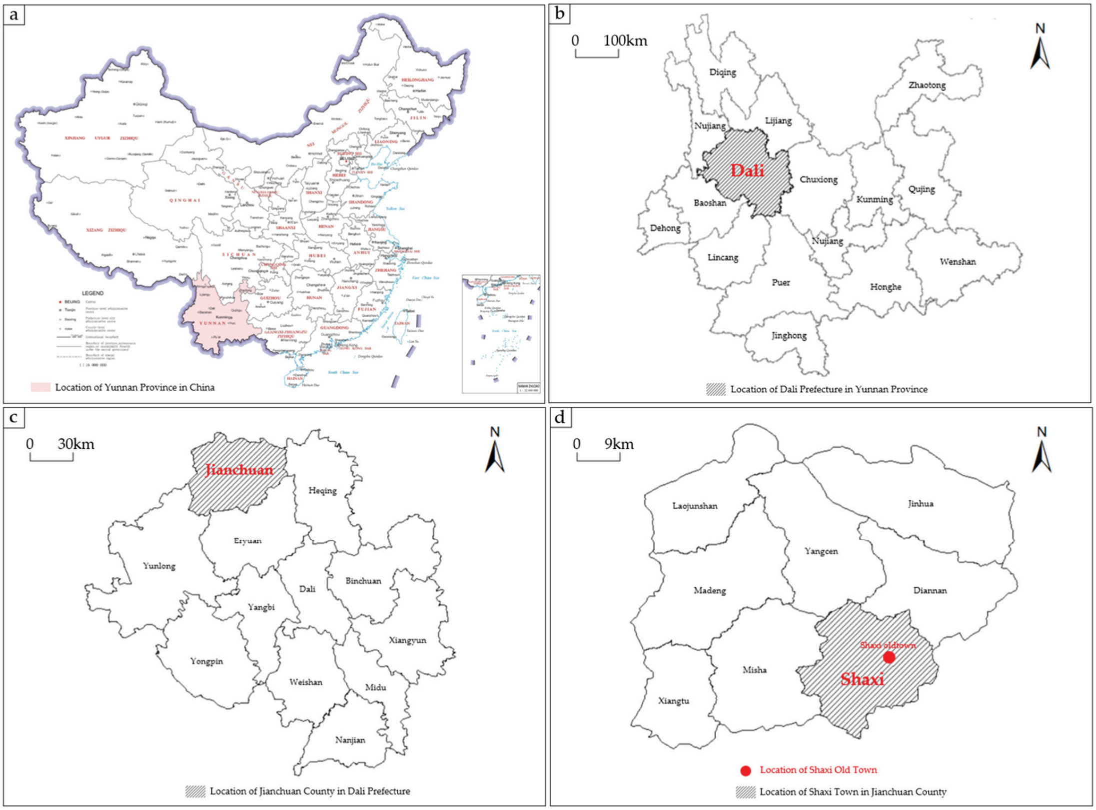

Figure 1. The geographical location of the study area. (**a**) Is from the Ministry of Natural Resources of China, and the review number is GS (2019) 1686. (**b**–**d**) are based on (**a**); the authors used ArcGIS software for self-mapping.

2.2. Research Methodology

2.2.1. Overall Idea

We begin by reviewing the literature and field research. We selected the historic town's protection area as our study location. Under the "Shaxi Historical and Cultural Town Conservation Plan", we also identified six old town building types by function. They are the Xingjiao Temple, the Patron God Monastery, the Ancient Theatre, the Essential Privileged Dwellings, the Generally Sheltered Dwellings, and the Stores. Second, we, local experts and craftsmen, discussed lucky on-site elements. They include the location (building components), symbolic significance, materials, and presentation methods. Then, we compiled a list of the lucky aspects found in each of the six buildings. Local experts are non-hereditary inheritors of traditional architecture and artisans have been building historic buildings for more than ten years. Finally, we calculate the auspicious element diversity index. It is to compare multicultural integration across architectural types. We also create a network model with propitious elements and get an index. It is to compare lucky culture compositions. Then, we compared and examined the calculations. It is to reveal the lucky cultural characteristics of classic old-town architecture. Next, the multicultural-indigenous culture link in the ancient town is investigated to exhibit the cultural perspective of the Bai people.

2.2.2. Determination of the Diversity of Auspicious Elements

In this study, each building type is considered a "community" and each auspicious element is considered a "species". During the field research, the Xingjiao Temple, the Patron God Monastery, and the ancient theatre were the only building groups in the old town. Therefore, only a single sample was selected. In contrast, the quality of the other three types of buildings varies. We discussed it with local experts in ancient architecture. Then, we decided on 20 representative samples of these three types of buildings. Richness and evenness [23] exemplify the diversity of lucky aspects the most.

1. Margalef index

This index reflects the richness of auspicious elements in each building type, which is calculated as follows.

$$D_{ma} = (S - 1)/\ln N \tag{1}$$

S is the number of auspicious elements in each building type, and N is the number of all individuals of auspicious elements in the building type.

2. Shannon–Wiener index

The Shannon–Wiener index describes the disorder and uncertainty in the occurrence of elements. A better Shannon–Wiener index score indicates a greater diversity of lucky elements. Its calculation formula is as follows.

$$H' = -\sum_{i=1}^{S} P_i \log_2 P_i \tag{2}$$

S is the number of auspicious elements in each building type and P_i is the proportion of elements belonging to cultural category i in the total number of features N.

3. Simpson's index

Simpson's index, also known as the dominance index, expresses how evenly the individuals in a community (buildings) are distributed among the different species (auspicious elements). The greater the value of Simpson's index, the greater the diversity of lucky elements. Moreover, its calculation formula is as follows.

$$D = 1 - \sum_{i=1}^{S} n_i(n_i - 1)/N(N - 1) \tag{3}$$

N is the number of all individuals of auspicious elements in the building type and n_i is the number of individuals of auspicious part i.

2.2.3. Analysis of the Characteristics of the Co-Occurrence Network of Auspicious Elements

The social network analysis (SNA) method originated from the sociology of measurement. It is also used to study how different people in society interact with each other. The fundamental premise is to construct a "network", using actors as "points" and their relationships as "links" [24]. Auspicious element co-occurrence networks are modelled, calculated, and examined in three steps. First, each auspicious part is considered a "node". There are different lucky elements in building components of the same building type. Co-occurrence describes the relationship between common auspicious elements. If two nodes happen to occur together, it is written as "1", and if they do not, it is written as "0". Next, we made a co-occurrence matrix of lucky elements for each building type. Then, we built each building type's "auspicious element co-occurrence network model" using Ucinet analysis software. Lastly, different metrics are used to look at how a network works, including the network's density, K-core, absolute centrality, intermediate centrality, degree centrality, and intermediate centrality. They are chosen to study each building type's auspicious element co-occurrence network model. Specifically, co-occurrence networks in structural stability and network centrality. The selected indexes are as follows.

1. Network density

Network density is the ratio of the network's actual number of connected relationships to its theoretical maximum. It is applied to measure the overall structural density of the network. As well as the degree of association between network components. It is calculated as follows.

$$P = L/[n(n - 1)/2] \tag{4}$$

P is the network density, L is the number of connections, and n is the number of nodes in the network.

2. K-core

The "K-core" is used to analyse the stability of the network's internal structure. Any point in the K-core network structure is adjacent to at least K nodes. The more stable the network topology is, the higher the K-value and the more influential the proportion of K-core.

3. Cut point

It refers to some nodes in a network. If removed, the whole network will be multiple unrelated parts. However, the network's vulnerability can appear by the number and proportion of cut points.

4. Degree centrality potential

The degree centrality potential is used to analyse the centrality of the network. Describe the overall tendency of nodes to congregate at a specific point in the network, and also quantify the network structure's degree of general equilibrium. The calculation formula is as follows.

$$C = \frac{\sum_{i=1}^{n}(C_{max} - C_i)}{max[\sum_{i=1}^{n}(C_{max} - C_i)]} \tag{5}$$

C_{max} is the maximum value of the degree centrality of each node in the network and C_i is the centrality of node i.

5. Intermediary centrality

The network's intermediary nodes are those in the shortest path between other nodes. Intermediary centrality, computed as follows, increases as nodes occur in linked courses.

$$C_{RBi} = \frac{\sum_{j}^{n}\sum_{k}^{n}\frac{g_{jk}(i)}{g_{jk}}}{n^2 - 3n + 2} \tag{6}$$

C_{RBi} is the relative intermediate centrality of nodes, $g_{jk(i)}$ is the number of paths that exist between node j and node k that pass through the third point i, $g_{jk(i)}$ is the number of ways that exist between node j and node k, and n is the total number of nodes.

6. Intermediary centrality potential

It looks at how evenly the intermediary centrality of all the nodes in the network is spread out. The formula for figuring out how to measure this is as follows.

$$C_B = \frac{\sum_{i=1}^{n}(C_{RBmax} - C_{RBi})}{n - 1} \tag{7}$$

C_B is the intermediary centrality potential of the network, C_{RBmax} is the maximum possible value of the intermediary centrality of a node, C_{RBi} is the actual value of the intermediary centrality of node i, and n is the number of nodes in the network.

3. Results

3.1. Cultural Connotation of Auspicious Elements

3.1.1. Expression of Auspicious Culture

We did a study and analysis in the area. The results showed us how Shaxi ancient town's Bai architecture symbolises luck. It takes the building components as the expression carrier. The pursuit of auspicious symbolism is expressed through decorative elements with auspicious meaning. Extensive woodwork, small woodwork, tilework, and colour painting are the principal expression carriers. In addition, there are stone carvings, column bases, and ridge decorations. (See Figure 2).

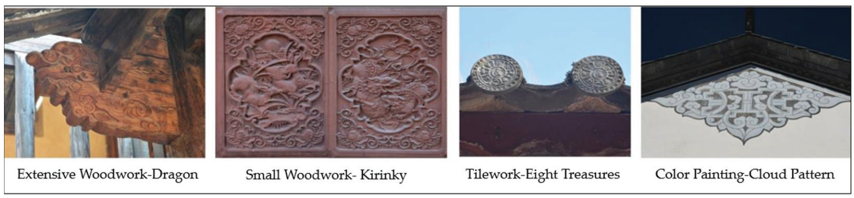

Figure 2. Pictures of auspicious elements.

3.1.2. Local Expression of Auspicious Elements in Bai Traditional Architecture

Table 1 shows that the Shaxi Bai people have fully absorbed and borrowed foreign culture. They were then forming a rich combination of auspicious factors. This is a local interpretation of Shaxi Bai's fortunate foreign architecture. Furthermore, it symbolises the lucky culture of traditional Shaxi Bai architecture. It is a fusion and development of multiple cultures and local Bai culture. It shows how accepting the Bai people are of other cultures. At the same time, it shows the inheritance of their own culture.

Table 1. The cultural connotation of auspicious elements [25,26].

Cultural Sources	Number	Auspicious Elements	Local Expression
Buddhist Culture	F1	Lotus	The lotus is the first of the eight Buddhist treasures of good fortune because the lotus is also known as "lotus" and "and" with the same sound, symbolising good luck and good fortune. The Bai people mostly use the lotus as harmonious auspicious symbolism.
	F2	Magpie	In Buddhism, the magpie represents good fortune and is also called the god of happiness. The Bai people often use the wood carving of "Magpie on the plum tree" or "Joy on the plum tree" on the door to signify the arrival of joyful events.
	F3	Elephant	The white elephant is a Buddhist beast, and Pu Xian, one of the Four Great Bodhisattvas of Buddhism, is a white elephant.
	F4	Curly grass	In the long-term historical development, the scrolling grass pattern is often associated with Buddhist decorative designs.
	F5	Chiwen	The Chiwen, a Buddhist protector, drives away evil, mainly in the form of fish and dragons.
	F6	Pomegranate	The pomegranate was introduced to China on the Silk Road, and the Bai people used it to signify many sons and blessings.

Table 1. *Cont.*

Cultural Sources	Number	Auspicious Elements	Local Expression
	F7	Lion	The lion is the mount and incarnation of Manjushri, and the Bai people take the lion as their primary protector and use the word "lion" to express the meaning of peace and good fortune.
	F8	Eight Treasures	The eight Buddhist treasures are the precious umbrella, the goldfish, the precious vase, the lotus flower, the dharma conch, the auspicious knot, the darling banner, and the Dharma wheel.
	F9	Ruyi	Ruyi is considered the spokesperson of Buddhism, and the Bai people use it to express auspiciousness, health, and longevity.
	F10	Peacock	The peacock is born from the phoenix in Buddhist mythology, and the Peacock King is one of the Tantric masters, which the Bai people use as a symbol of beauty.
	F11	Pisces	The double fish is one of the eight auspicious things in Tibetan Buddhism in China, representing Buddha's two eyes.
	F12	Swastika pattern	The swastika is one of the thirty-two great appearances of the Buddha.
Taoist Culture	D1	Foo (Bat)	The word "Fu" is homophonic with "bat", and the Bai people often use the image of a bat to represent the meaning of blessing and prosperity.
	D2	Locus	"Lu" and "deer" have the same sound, Taoism with the concept of immortality, the deer as a "life of a thousand years" thing, is a symbol of longevity. The Bai people mostly use the "deer and crane with spring" or "six contracts of longevity" pattern to symbolise longevity and good fortune.
	D3	Longevity	The Longevity Star is one of the three stars of Taoism, and the Bai people use longevity to express the meaning of longevity and good fortune.
	D4	Like	Xi is derived from Taoist mythology and is used by the Bai to express joy.
	D5	Crane	The crane is a bright Taoist object, and the Bai people use it to express the meaning of longevity and the prosperity of all things.
	D6	Dragon	The dragon originated from Taoism, and the Bai people use it as a bright object. The Bai use it to express peace, good fortune, and peace in their homes.
	D7	Rabbit	The "jade hare pounding medicine" is a Taoist allusion commonly found on the Baigfan door, signifying longevity.
	D8	Plum (Compound petal pattern)	In Taoism, the plum blossom represents the realm of Yang Sheng, and the Bai's door is often decorated with a combination of plum blossoms and magpies to signify "joyfulness".
	D9	Gourd	The gourd is a representative plant of Taoism.
	D10	Plantain	The plantain is a representative plant of Taoism.
	D11	Peach	The peach is a Taoist immortal fruit used by the Bai to ward off demons on the one hand and signify longevity on the other.

Table 1. *Cont.*

Cultural Sources	Number	Auspicious Elements	Local Expression
	D12	The Eight Immortals	The Eight Immortals are the eight Taoist gods and goddesses, and there are famous sayings such as the Eight Immortals crossing the sea.
	D13	Pine	Pine is closely associated with Taoist culture and is known as the immortal of trees, used as a metaphor for longevity and longevity. The Bai people often use it as a symbol of longevity and purity.
	D14	Chrysanthemum (Spoke pattern)	The chrysanthemum is synonymous with "contentment" in Taoist thought. The Bai people use the chrysanthemum pattern as one of the themes for decorating the Bai lattice fan door, mainly for its cold resistance, unchanging quality, and meaning of longevity.
Confucianism	R1	Kirin	The symbol of the Bai people's literary thinking and optimistic attitude towards life is the "Kilin sending papers".
	R2	Phoenix	The phoenix is a Confucian sacred animal. Because of its divine qualities of omen, virtue, metaphorical love, and warding off evil, the Bai see it as a symbol of good fortune, love, and national culture.
Bai Culture	B1	Tile Cat	The tile cat is one of the representatives of the native culture of the Bai people and is used to avoid evil spirits, receive good fortune and calm the house.
	B2	Golden chicken	The chicken is called the "Golden Rooster", as totem worship of the Bai people because the "Gong" of the rooster and the "Gong" homophonic are applied to signify merit and wealth.
	B3	Tiger	Bai people, still white, worship the white tiger. Bai people call themselves "Bai Zi", "Bai Luo Luo", and "Luo" is the white language "tiger". "Luo" means "tiger" in the Bai language.
Commercial Horse Culture	C1	Horse	As an essential ancient marketplace on the old tea horse route, the horse was a necessary means of transportation, and its use as an auspicious ornament meant smooth sailing.
Traditional Folk Culture	Z1	Palindromic pattern	It meant auspicious, deep, and long. The Bai often back to the pattern as a secondary decoration to highlight the main body, forming a contrast effect between the background and the main body.
	Z2	Cloud pattern	As an ancient Chinese auspicious motif, symbolising high ascension and good fortune, the Bai often use cloud patterns together with images of sacred animals and beasts to highlight the carved subject and make painted decorations at a later stage to play a role in praying for blessings.
	Z3	Peony	The peony is an essential subject of traditional Chinese art. The Bai lattice fan doors are often decorated with "phoenix through peony" motifs to signify good fortune, beauty, and prosperity.
	Z4	Bogu	The Bo Gu decoration originates from traditional Chinese culture, and the Bai people use it to express their knowledge of the past and the present and their respect for elegance.
	Z5	Bamboo	Bamboo is a metaphor for a talented gentleman and has the auspicious meaning of "Broadcast peace".

3.2. Identification and Quantification of Auspicious Elements

Table 2 lists and quantifies auspicious decorative elements. There were identified 26 auspicious elements from Xingjiao Temple; 25 auspicious factors in the Patron God Monastery; 21 auspicious aspects from the ancient theatre; 25 auspicious elements from the essential protected dwellings; 26 auspicious elements from the generally covered dwellings; and 23 bright factors from the stores. Different building types use different decorative elements to express lucky culture.

Table 2. Extraction table of auspicious elements.

Building Type	Element Name	Number	Total
Xingjiao Temple	Magpie, Crane, Deer, Rabbit, Elephant, Lion, Dragon, Chiwen, Kirin, Phoenix	10	26
	Bamboo, Pine, Curly Grass, Pomegranate, Chrysanthemum, Plum, Lotus	7	
	Horse, Pisces, Compound Petal Pattern, Spoke Pattern, Buddhist Eight Treasures, Ruyi, Palindromic Pattern, Cloud Pattern	8	
	Bogu	1	
The Patron God Monastery	Magpie, Crane, Deer, Peacock, Kirin, Bat, Lion, Dragon, Elephant, Chiwen, Phoenix	11	25
	Pine, Peach, Plum, Gourd, Curly Grass, Peony, Lotus, Plantain	8	
	Cloud Pattern, Horse, Longevity, Spoke Pattern, Compound Petal Pattern	5	
	Bogu	1	
The ancient theatre	Crane, Tiger, Chiwen, Golden Rooster, Horse, Lion, Phoenix, Dragon, Elephant	9	21
	Pine, Plum, Curly Grass, Chrysanthemum, Lotus	5	
	Longevity, Spoke Pattern, Compound Petal Pattern, Horse, Palindromic Pattern, Cloud Pattern	6	
	Eight Immortals	1	
The essential protected dwellings	Dragon, Peacock, Crane, Phoenix, Horse, Magpie, Rabbit, Kirin, Bat, Deer	10	24
	Plum, Chrysanthemum, Peach, Pine, Peony, Curly Grass, Lotus	7	
	Like, Cloud Pattern, Spoke Pattern, Horse, Compound Petal Pattern, Palindromic Pattern, Swastika Pattern	7	
	Bogu	1	
The generally protected dwellings	Magpie, Peacock, Deer, Rabbit, Phoenix, Dragon, Elephant, Tile Cat, Crane, Bat, Kirin	11	26
	Plum, Chrysanthemum, Curly Grass, Pine, Peony, Lotus	6	
	Horse, Like, Compound Petal Pattern, Spoke Pattern, Cloud Pattern, Longevity, Palindromic Pattern, Fu	8	
	Bogu	1	
Stores	Kirin, Rabbit, Phoenix, Magpie, Crane, Dragon, Deer	7	22
	Peony, Plum, Pomegranate, Pine, Chrysanthemum, Lotus, Curly Grass	7	
	Horse, Like, Spoke Pattern, Compound Petal Pattern, Cloud Pattern, Palindromic Pattern, Longevity	7	
	Bogu	1	

3.3. Diversity of Auspicious Elements

3.3.1. Diversity of Auspicious Elements of Each Building Type

Table 3 shows that: The Patron God Monastery has the highest Margalef index and Simpson index. At the same time, its Shannon–Wiener index is also a higher value. It means that one type of building out of the six has the most richness and evenness. It also shows that it is the building in the old town with the most diverse lucky elements. Moreover, three diversity indicators of Xingjiao Temple are near the Patron God Monastery. It indicates that the diversity of lucky elements in Xingjiao Temple is high. The three diversity indexes of the ancient theatre are the lowest. It means that it is the building in the old town that has the lowest number of diverse lucky elements because it has only a single performance function.

Table 3. Diversity of auspicious elements by building type in Shaxi.

Building Type	Dma	Ds	H′
Xingjiao Temple (XT)	7.2135	0.9819	4.5625
The Patron God Monastery (PGM)	7.7213	0.9877	4.5561
The ancient theatre (AT)	5.9395	0.9754	4.2542
The essential protected dwellings (EPD)	6.4691	0.9630	4.3217
The generally protected dwellings (GPD)	6.6887	0.9663	4.4516
Stores (S)	6.2365	0.9803	4.3492

For ease of representation, the parentheses in the table are shorthand for the sample, such as Xingjiao Temple (XT), similarly after this. And D_{ma} is the Margalef index; D_s is the Simpson index; H′ is the Shannon–Wiener index.

Table 3 also shows that the three indexes of the generally protected and the essential protected dwellings are close. It was possible to verify that the two building types are the same because of the fast growth of tourism and urbanisation. Most generally protected homes have been turned into stores and inns for tourists. Therefore, it brings different cultures. It may also explain why the store's three indicators are near the generally protected dwellings.

3.3.2. Diversity of Auspicious Elements of Traditional Architecture in Ancient Towns

Table 3 shows that the Simpson indexes of all six building types in the ancient town are close to 1. This indicates that the historic town's lucky elements of traditional buildings are diverse. It reflects their multicultural background due to history, tourism, and urbanisation.

3.4. Analysis of Auspicious Element co-Occurrence Network Characteristics

3.4.1. Overall Network Completeness

Figure 3 shows that the generally protected dwellings and stores are the two building types with a high network density. This indicates that their network structure is complete and they have a high degree of node connectivity. In contrast, the network densities of the other four building types are relatively close. From high to low, they are the ancient theatre, the Xingjiao Temple, the essential protected dwellings, and the Patron God Monastery, in that order. The network density represents the degree of completeness and it shows the closeness of the network structure of auspicious elements. It reflects the degree of auspicious cultural integrity. For example, generally protected dwellings and stores are two typical types of buildings because they are the most influenced by tourism in ancient towns. The high network density indicates their high level of multiculturalism. In addition, the Xingjiao Temple, the Patron God Monastery, and the ancient theatre are representative public buildings in the old town. The government protects them, which leads them to being less influenced by the new foreign culture so their network density is lower.

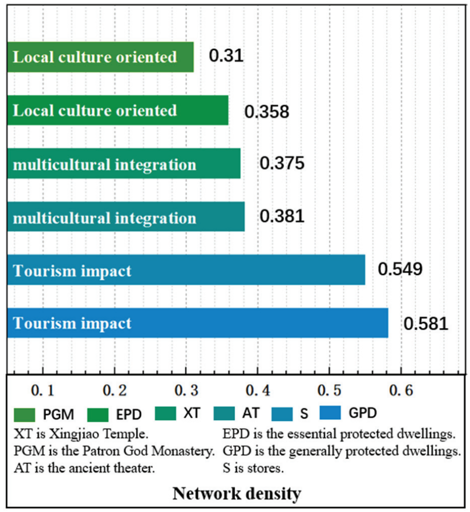

Figure 3. Co-occurrence network density bar graph.

3.4.2. Network Local Stability

Figure 4 shows that each type of building in the old town is made up of a group of lucky elements with stable structures and close links. They reflect the parts that have a particular way of being put together to show the lucky culture. Each building type forms a unit cluster family with different cultural meanings. It suggests that the old town's lucky culture comes from a blend of cultures.

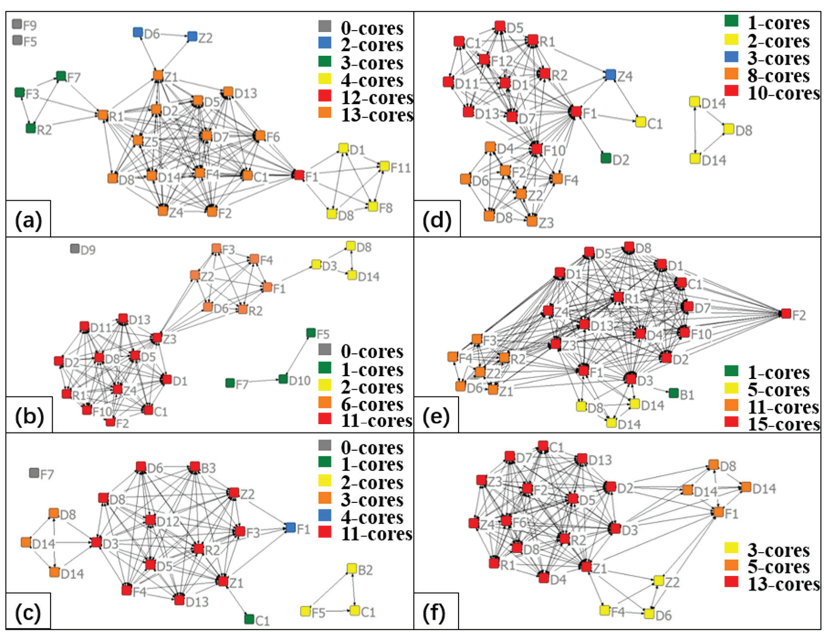

Figure 4. K-core diagram of auspicious elements for each building type. (**a**) is Xingjiao Temple, (**b**) is the Patron God Monastery, (**c**) is the ancient theater, (**d**) is the essential protected dwellings, (**e**) is the generally protected dwellings, (**f**) is Stores.

3.4.3. Network Vulnerability

Table 4 shows the number of cut points of all architectural types of auspicious elements below 3. The co-occurrence network of lucky architectural elements is relatively safe. Moreover, all of them have formed a stable network structure. In addition, F1 (lotus flower) is the most frequent auspicious element in each building type. It reflects the more significant Buddhist impact on historic town auspicious constructions.

Table 4. Co-occurrence network cut points of auspicious elements by building type.

Building Type	Cutting Point	Number
Xingjiao Temple (XT)	F1 (Lotus), R1 (Kirin), Z1 (Palindromic pattern)	3
The Patron God Monastery (PGM)	F1 (Lotus), D3 (Longevity), D10 (Plantain)	3
The ancient theatre (AT)	D3 (Longevity), Z1 (Palindromic pattern)	2
The essential protected dwellings (EPD)	F1 (Lotus)	1
The generally protected dwellings (GPD)	F1 (Lotus)	1
Stores (S)	None	0

3.4.4. Intermediary Centrality

Figure 5 indicates that every building has lucky parts with high intermediate centrality. They are at the heart of the building types' fortunate elements. Each historic town building has a primary and secondary auspicious aspect. Individually, each building type almost always contains the lucky element F1 (lotus). Moreover, it has high intermediate centrality values. The lotus is vital to the ancient town's auspicious architecture. Furthermore, it also reflects Buddhism's relevance in Shaxi's old town's fortunate architecture.

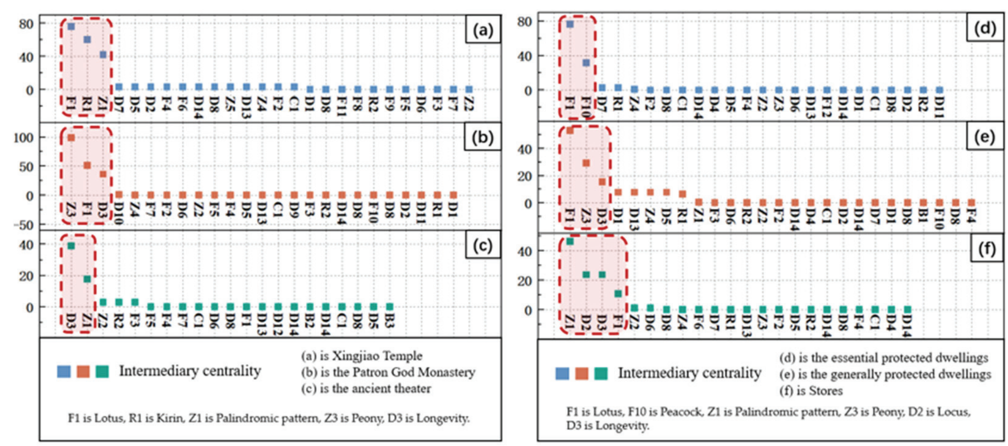

Figure 5. Scatterplot of intermediary centrality in descending order.

3.4.5. Degree Centre Potential

Figure 6 shows that the degree centrality potential of EPD (55.73%) is significantly higher than the other five building types. It indicates other building types' poorer integrity. However, the network degree centrality of EPD is apparent. It reflects that foreign cultures and better protected with less impact. In addition, most of EPD are residences of historically famous families. The owners have good economic ability and a high cultural level. It leads to the owners having significant autonomy in selecting auspicious elements. Therefore, there is a prominent theme in expressing auspicious culture in EPD. Moreover, the degree centrality potential of Xingjiao Temple (28.67%) is at the lowest level. It indicates that its network centrality is poor and its balance is high.

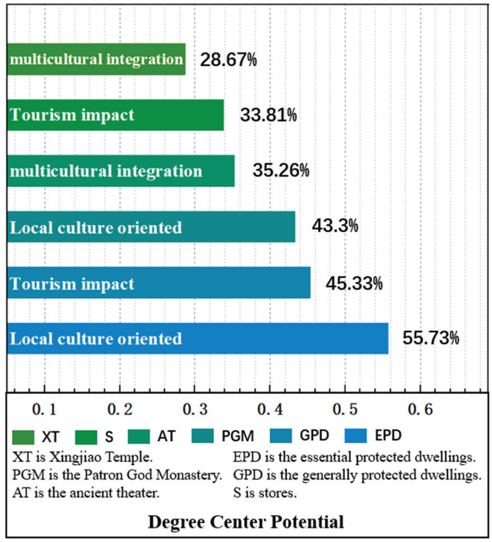

Figure 6. Bar chart of degree centre potential.

3.4.6. Intermediary Centre Potential

Figure 7 shows that the PGM's intermediary centrality potential (34.54%) is high. This indicates that its overall intermediary centrality potential is high. It also shows that the overall centrality of its network is increased. This is due to the nature of the temple as a typical building of the Bai's unique Lord worship culture. Therefore, its ability to resist the impact of foreign culture is vital. In contrast, the intermediary centrality potential of GPD (16.63%) is low. It indicates that its overall intermediary centrality is low. Meanwhile, the overall centrality of the network is low. This reflects the more homogeneous distribution of auspicious elements. It reflects the more significant impact of foreign culture brought by tourism development.

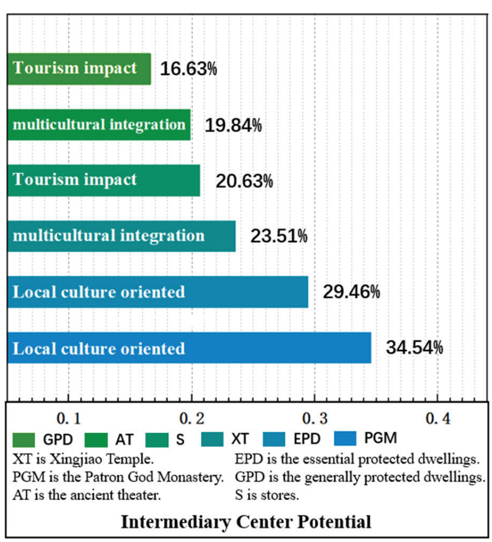

Figure 7. Intermediary centre potential bar graph.

4. Discussion

4.1. Shaxi Bai Traditional Architecture Auspicious Cultural Expression

This study demonstrates that wood, stone, and other decorative arts are employed frequently. The structure has extensive woodwork, small woodwork, bright paintings, and tiles. They are the main thing that people express lucky culture. On the one hand, several research studies on lucky architectural ornamental designs [27–30]. They focused on extensive and small woodwork, ridge creatures, pedestals, and brilliant paintings. However, the tiles are rarely included as an architectural element. On the other hand, much research has investigated the tile pendant's lucky culture [31–33]. Nevertheless, most have concentrated on tile pendants as a distinct architectural component. The study revealed that each building type's lucky elements cluster into unit clusters. Moreover, tile pendants play a particular function in the manifestation of lucky culture. Based on this, the tiles should form a complete system with other elements. It is used to study the lucky details in traditional architecture. It provides a new perspective on building preservation and renovation.

4.2. Traditional Village Development Issues Reflected by the Diversity Levels of Lucky Elements

In this study, the diversity levels of each building type's lucky elements are close. It showed that all building types display auspicious features diversely. For example, most of the essential protected dwellings were famous family homes. Their economic and cultural levels were higher than the generally protected dwellings. Therefore, their need to express their lucky culture was higher than in other dwellings. In contrast, the generally protected dwellings are now occupied mainly by ordinary villagers. They should define lucky culture as less than the essential protected dwellings. However, this study indicates that the original gap between them is narrowing. It is because the expansion of tourism has had a significant impact on how people in general live. Most of these dwellings are now being transformed into tourist inns. The essential protected dwellings are learning objects during rehabilitation. The different cultural backgrounds of the owners of tourist inns. Together, they diversify the lucky elements of the two building types. It reflects the multi-cultural integration feature in traditional villages' development process. Furthermore, it illustrates many traditional villages' development issues [34,35]. Traditional settlements must balance different cultures with the original. Perhaps increasing the cultural confidence of local villagers is a solution [36].

4.3. Factors Influencing the Expression of Auspicious Culture in Traditional Shaxi Bai Architecture

4.3.1. The Influence of Multiculturalism and Local Culture on the Expression of Bai Auspicious Culture

This study shows that the mediation centrality of the Patron God Monastery is at a high level. Therefore, it is an architectural type with high network centrality. It reflects its high degree of resistance to the impact of foreign culture. It also reflects its thematic expression of auspicious culture. Moreover, this is caused by the strong local culture of lord worship. Some scholars considered Bai lord worship a "cultural confrontation" [37]. It maintains social order and reconstructs local cultural significance. Furthermore, it is compatible with the findings of this study. This study found Xingjiao Temple's auspicious element network less central. It reflects that the lucky aspects are more equal. Furthermore, it demonstrates the diversity of its auspicious cultural expression. Xingjiao Temple is a representative public building. It combines Buddhist Acharya, Taoism, Confucianism, Bai culture, and commercial horse culture. Therefore, mixing cultures creates a more uniform and diverse lucky culture.

Traditional architecture's dominant culture influences auspicious culture. Lucky culture is the dominant culture's outward expression. The Bai people have a custom of worshipping the lord. The temple of the local lord has become an essential part of the Bai villages. Because it is where people go to worship, this is why the native culture has stayed the same. It shows how strong the native culture is and how confident the Bai people are in their culture.

Traditional villages should be passed down and kept safe for as long as possible. Furthermore, both the local culture and the foreign culture should be accepted. Today, many traditional villages must unite people of different cultures, so many villages have become similar, and the area's culture is slowly dying out. However, the old town of Shaxi is a good example. The local culture may depend on the people's confidence in their culture.

4.3.2. The Influence of Buddhist Culture on the Expression of Bai Auspicious Culture

This study indicates that the lotus flower is central to Shaxi Bai architecture. Moreover, the lotus flower is the first of the eight Buddhist treasures. Reflecting the significant influence of Buddhism on Bai culture, Dali was known as the "Land of Myriad Fragrances and Buddhism". Many kings of Dali practised Buddhism during the Dali period. The study [38] demonstrates that Buddhism significantly impacted Dali's Bai government. It also spreads culture, education, and societal standards. As a result, Buddhist culture plays a vital role in expressing the auspicious culture. It is the most common element of good luck in the traditional architecture of the Shaxi Bai.

4.4. Strategies for the Preservation and Development of the Auspicious Culture of Traditional Shaxi Bai Architecture

The traditional architecture of the Shaxi Bai has its way of showing that things will go well. In terms of public architecture, the Xingjiao Temple is a Buddhist-dominated public building. Moreover, the Patron God Monastery is a public building dominated by the native culture. Due to dominating culture, they have various auspicious elements. At the same time, these buildings are also icons of Shaxi Bai's traditional settlement. Development and changes are prohibited from perpetuating their dominant cultural status. According to researchers, "repair the old as the old, minimising intervention and maximising preservation" [39]. In terms of residential architecture, a unified conservation standard should be issued. The essential protected dwellings have significant historical and cultural value. They should avoid over-growth and blind development. In contrast, the generally protected dwellings should be built sensibly. This way fits within the rules of conservation. It is to meet the social needs of the tourism industry, which is proliferating. Cultural integration is a general trend. It has led to an increase in auspicious cultural diversity. Building local communities' cultural confidence is the essential solution. Furthermore, the Patron God Monastery is a good example.

5. Conclusions

Shaxi ancient town is "the only surviving ancient market in the world". Bai culture has been exchanged and absorbed here from ancient times. However, today's rapid tourism development and urbanisation. It has led to a deepening cultural fusion in the town. Traditional architecture is an essential part of traditional villages. Overdevelopment and ethnic and cultural loss challenges are severe threats today. We started with the auspicious culture of Shaxi Bai's traditional architecture. We then analysed the old town's auspicious elements, auspicious cultural expression, and cultural influences. Shaxi Bai's traditional building shows off its lucky cultural traits. The study concludes that Buddhist culture affected Shaxi Bai's traditional architecture. However, the Bai people also keep and spread the local culture. It reflects the coexistence of multiple cultures. Moreover, the Patron God Monastery shows its confidence in the local culture. It is this characteristic that they show when facing cultural integration. The study's results show how the Bai people feel about their culture and how confident they are. It has led to their acceptance of multiculturalism without losing their native culture as well as understanding how to inherit and develop the culture in traditional architecture. The cultural outlook of the Bai people may be a good case to discuss.

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Article

Spatial Reconstruction and Cultural Practice of Linear Cultural Heritage: A Case Study of Meiguan Historical Trail, Guangdong, China

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Abstract: Linear cultural heritage is a unique and emerging type of large-scale heritage primarily located in rural areas. Despite the fact that much literature has concentrated on the importance of heritage to rural revitalization and development in Western countries, linear cultural heritage production has remained largely absent from accounts of rural studies in the context of China. This article aims to address this neglect by examining the spatial reconstruction process of the Meiguan Historical Trail. Based on the theory of the production of space, this article reveals the cultural practice of local ruling elites in mobilizing linear cultural heritage to promote regional competitiveness and how ordinary people question the official space reconstruction policy. The article finds that residents are obedient to government's efforts, while tourists are suspicious of the superficial cultural restoration. The findings further deepen the understanding of linear cultural heritage production as a rural development location policy. In addition, as an important dynamic force, culture participates in the spatial production of linear cultural heritage, which enriches the cultural dimension of spatial production to a certain extent. The findings offer theoretical direction and policy recommendations for the development and sustainability of linear cultural heritage worldwide.

Keywords: linear cultural heritage; production of space; cultural practice; Meiguan Historical Trail; cultural heritage protection project

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1. Introduction

As a precious treasure of human beings, linear cultural heritage (LCH) is referred to as the cultural heritage agglomeration in the linear geographical space with features of wide spatial span, prominent theme and diverse cultures, among others. With the continuous expansion of the protection concepts of the European cultural route [1,2] and the American heritage corridor [3,4], people have gradually realized the vast economic benefits of heritage, and the world has set off a boom in the protection and development of LCH [5–7]. The Camino de Santiago in Spain and Route 66 in the USA are well known, but there are many lesser-known examples in developing countries. Protecting cultural heritage is a challenge for developing countries, particularly where heritage sites are widely spread in rural areas and may not include impressive buildings and monuments.

The large-scale spatial pattern has led to many problems in the tourism development of LCH and villages that classify as linear [8]. For example, the destruction and disappearance of some heritage sites have led to the loss of the theme of LCH [5]. Moreover, the assimilation of tourist landscapes that classify as linear have cut off the historical background [9]. In addition, the tourist landscapes that classify as linear are fragmented, which makes it challenging to form regional solid tourism competitiveness [10]. A potential solution adopted by a growing number of these countries is to link small sites of mainly local significance into a cultural heritage route and market them as a package while also improving the management and conservation of heritage assets [11]. Although much literature has focused on the centrality of heritage to rural revitalization and development, the production of LCH has remained largely absent from accounts of rural studies.

China's 5000-year-old culture has given birth to many linear cultural heritage sites, such as the Silk Road, the Grand Canal, the Great Wall, the Tea-Horse Historical Trail, the South China Historical Trail, and the Central Axis of Beijing. The South China Historical Trail is an important channel for connecting home and abroad to the Maritime Silk Road on land. It is also a critical cultural practice for the Guangdong Province to realize regional economic development. In China, the central government accelerates national economic development by giving the local government a certain degree of autonomy in developing the local economy. Spatial reconstruction is often included in the growth engine [11]. In order to enhance the region's image, large-scale restoration projects are becoming more and more common. For decades, the government has been packaging its historical landscapes or other heritage sites into heritage products to improve the region's competitiveness in the global tourism industry [11,12]. Its primary purpose is to help the region effectively realize the economic transformation from traditional to more profitable service industries. In particular, during the economic transition period, tourism is the leading force in promoting rural construction and revitalization. Many rural tourist destinations have conducted tourism development based on heritage resources [13], which has promoted changes in the rural landscape, infrastructure, and lifestyle and brought social, economic, and environmental benefits to the local area [14,15]. The exploration of the spatial reconstruction process of LCH based on cultural value is related to the sustainable revitalization and utilization of LCH and the villages that classify as linear.

This paper takes Lefebvre's spatial production theory as the fundamental analysis framework. It combines the follow-up research of Harvey and Foucault to effectively connect "culture" as the core element of spatial production theory. The case study of the Meiguan Historical Trail (Figure 1) aims to reveal that LCH is integrated into locational policies to accrue rural competitiveness and promote rural revitalization. Through this analysis, the article will shed light on how local governments in China mobilize LCH for economic growth and political control and how culture plays a role in the spatial reconstruction of LCH. Placing cultural heritage at the core of regional economic strategy, this paper understands it as the key to "regional economy and social wealth" [16].

Taking the Meiguan Historical Trail in Guangdong as an example, this paper aims to put forward new thoughts about the development of LCH. In particular, it includes the following objectives:

1. To illustrate the local government's efforts to reconstruct the LCH to promote the development of the villages that classify as linear.
2. To analyze the dynamic role of culture in this process and explain how residents and tourists react to the reconstruction project of LCH.
3. To deepen the understanding of linear cultural heritage production as a rural development location policy. Based on the above objectives, this study not only deepens theoretical research about space production and LCH reuse but also provides a reference for the sustainable development and policy making of LCH.

Figure 1. The location of Meiguan Historical Trail. Source: Google Maps.

2. Literature Review

2.1. Linear Cultural Heritage

Concepts similar to LCH include the ideas of "cultural route" and "heritage corridor". However, these three concepts originate from different social backgrounds and have strong time and place characteristics [6]. The cultural route mainly originates from European countries, and this concept is accompanied by the political and cultural demands required for developing European integration. As the world's first cultural route heritage selected for the "World Heritage List", the routes of Santiago de Compostela are regarded by the European Commission as a carrier for carrying collective memory, as well as crossing borders and language barriers, to seek cultural identity for different countries and nationalities in Europe [17]. After more than 30 years of development, related research has gradually been enriched, focusing on the classification of cultural routes, such as railways [18], canals [19], and pilgrimage routes [20], as well as tourism-related research, such as economic promotion [21], ecological protection [22], and sustainable development [23,24].

The heritage corridor is rooted in the vast natural environment of the United States. It has neither political demands for "identity" at the national or international level nor the meaning of "national symbol". It manifests itself as "a linear landscape with a collection of special cultural resources" [25]. The heritage corridor emphasizes the overall understanding of the historical and cultural value of the corridor, uses heritage to achieve economic revival, and solves problems, such as landscape similarities, the disappearance of community identity, and economic recession [6]. This shows that the core goal of the heritage corridor is to help the economic development of the areas that classify as linear through heritage protection. This approach's spillover effect beautifies the natural environment, enriches the cultural landscape, and forms a community identity. By protecting cultural elements along the heritage corridor, the linear space, not originally known as "heritage", has become increasingly cultural. Overall, compared with the cultural route, the heritage corridor has more grassroots characteristics. It is used as a strategy or planning method for local development rather than starting from heritage protection, such as cultural routes, as an objective type of heritage.

Judging from the research, the cultural route and heritage corridor are important theoretical references for the study of LCH in China. Due to the spatial distribution and the quantitative advantages of heritage types, most scholars believe that LCH belongs to cultural heritage agglomeration [10,25]. The morphological characteristic of LCH is another crucial point emphasized, and it is always expressed in terms of "belt", "edge", "strip", and "corridor" [6]. In terms of vocabulary composition, LCH is a cross-cutting concept composed of three words: "linear" refers to the extension of space; "culture" is its essential attribute; "heritage" corresponds to the value identity of modern society. It suggests that LCH is a vital link formed for the specific purpose of humanity. It connects some originally unrelated towns or villages to form a chain-like state of cultural heritage [25]. The connotation of LCH can be explained by subject, completeness, and authenticity. The cultural background of the linear space reflects the subject [6,26,27], while the geographical characteristic reflects completeness [22,28] and authenticity is the fundamental attribute of cultural heritage [29,30].

2.2. Space Production and Cultural Practice

Following Marx's idea of "spatial criticism", Lefebvre's theory of spatial production set off a research boom in "spatial transformation" [31]. Space production refers to the process by which space is produced, constructed, and reshaped under various political, economic, and social forces. In the process, space broke through the rigid constraints of the physical form, extended from materialized entities to the spiritual and social realms, and gradually spread to the entire social structure. Space became a mapping of social relations and social practices [32,33]. Since the 1990s, the theory of spatial production has become an essential perspective for explaining China's contradictory relationship between people and land and the binary structure of urban and rural areas. It is worth noting that the "visible hand" of the government has a significant position in China's socioeconomic development. Therefore, it is necessary to re-examine the social relations in the process of spatial production from a liberal perspective and outside the framework of the market economy [34].

Harvey used and disseminated Lefebvre's view earlier. He believed that spatial organization and structure are the needs and products of production [35]. He constructed the "triple cycle of capital" model, arguing that the three elements of spatial production theory are capital, class, and superstructure [36]. In practice, capital and class always appear together. However, in the context of Chinese society, it is necessary to focus on the role of political factors in space production. In particular, in many practices, such as rural reconstruction, heritage restoration, and utilization, relevant legal systems and planning skills must give legitimacy to certain types of space production. In addition, the production of a series of pieces of "knowledge", such as expert discourse and public opinion, also affects the direction and mode of spatial production [37,38]. That is, the state and representation work together.

In addition, Foucault believes that power is the prerequisite and condition for space to be produced, and space is a necessary tool for power operation [39]. His analysis of power relations provides a new perspective and method for spatial production. Unlike Harvey, Foucault emphasizes micro-scale practice and the importance of power. On the one hand, the ways of granting power are rich and diverse, including capital and knowledge; on the other hand, the different types of power possessed by different subjects are also very different, which echoes the problem that "class" is difficult to define by a single standard. Therefore, this paper replaces "class" with "power subject" and tries constructing a theoretical framework of spatial production with capital, power subject, and superstructure as the core.

Since the 1990s, culture has received increasing attention as an important driving force for promoting rural development. In the process of cultural-oriented rural revitalization, economic and political purposes are often hidden but permeate the process of cultural heritage brand construction with cultural elements as the carrier [40]. In the extension of the space field, the spatial production caused by tourism has gradually received attention. Moreover, attention as a representative method outlines a new research paradigm for deconstructing the social and natural space [41], reflecting the design and shaping process of various production methods and social elements of the destination in the tourist space. It more intuitively shows the concept and pattern of space production.

In summary, the theory of spatial production shows the characteristics of multiple intertwining perspectives in the field of discipline and research, and the research direction provides a theoretical reference for explaining the mechanism of the rebirth of heritage. The theory of space production overemphasizes the dominant role of capital and power in space production and, to a certain extent, ignores the critical role played by cultural factors in it [42]. Therefore, it is necessary to re-examine how to embed cultural factors in spatial production rather than limiting it to a means or tool. Multiple forces will regulate cultural forms, but culture will also dynamically shape people's identity and imagination through various forms of representation [43]. This research uses the course of time as the clue and embeds culture around it based on the spatial production analysis framework of capital, power subject, and superstructure; explores the spatial production mode and mechanism of LCH in the process of its restoration and utilization; and further extends and expands the theory of spatial production.

3. Research Context and Methodology

3.1. Description of the Study Area

As an important part of the South China Historical Trail, Meiguan Ancient Road is located in Nanxiong, Shaoguan, Guangdong Province. It originated in the Tang Dynasty and spatially starts at Zhuji Ancient Lane in the south and ends at Meiguan Guanlou in the north. With a length of 18km, it passes through Shitang Village, Lingtan Village, Zhongzhan Village, Meiling Village, and other villages. As the only land passage in the Jingguang Historical Trail, the Meiguan Historical Trail is also known as the landmark of the ancient Silk Road on land and has played an essential role in trade and cultural exchanges. After various periods of repair and maintenance, Meiguan Historical Trail is full of plum blossoms, and the natural ecological landscape is of outstanding value. However, since 1949, the highway connecting Dayu and Nanxiong opened to traffic, and the Meiguan Historical Trail was gradually replaced by the Xiongyu Highway, experiencing silence for nearly 40 years.

In 2004, the Nanxiong Government issued the "Nanxiong Tourism Development Master Plan", which involved the tourism plan for Meiguan Historical Trail. However, the ancient villages and historical sites that classify as linear were scattered around, which made it difficult to activate and use. After the activation and utilization project of the South China Historical Trail covering 1320 villages within 5 km that classify as linear, the Meiguan Historical Trail received financial support from the provincial government in 2016. With the cooperation of the government and the Guangdong Volunteer Association of Planners, Architects, and Engineers (professional and technical personnel represented by planners, architects, and engineers, referred to as the "Third Division Professional Volunteer Association"), the restoration and utilization of the Meiguan Historical Trail was fully launched. Meiguan Historical Trail has gradually transformed from its original residential space to a cultural consumption space integrating leisure tourism and sports. Tourism revenue has also multiplied from CNY 6.46 million in 2016 to more than CNY 200 million in 2018, and tourism has developed rapidly.

3.2. Research Design and Data Collection

Semi-structured interviews with different stakeholders were mainly applied to collect data. From September 2019 to June 2021, the authors went to Meiguan Historical Trail six times to conduct fieldwork for 35 days. These interviews with residents were mainly carried out after the authors lived in their guesthouses or consumed at their restaurants and established interpersonal relationships with those people, ensuring sufficient interview time and depth. Access relied on the introduction via local government, directly approaching villagers, and snowball sampling processes. The purpose is to reveal various actors' agency in the spatial reconstruction process and their perception of LCH. In total, we conducted 46 interviews in Mandarin with government officials, residents, and tourists. The in-depth interviews lasted from 30 min to one hour. Some respondents were interviewed twice or thrice for clarification. They were taped with permission and subsequently transcribed. All names are fictitious to ensure anonymity. Additionally, the interviewees are initially coded according to the coding rules of "interviewee identity - interviewee order" (Table 1). Among the main types of interviewees, R represents local villagers, G represents government administrators, V represents volunteers of the "Three Teachers Association", and T represents tourists. The last number is the order in which people of the same identity are interviewed. This paper used 46 interview samples from the field survey database, and the interview data were transcribed into more than 98,000 words in Chinese.

Table 1. List of interviewees.

Number	Gender	Age	Identity	Number	Gender	Age	Identity
R1	M	45	Resident, Meiling Village	G7	M	42	Village Committee, Lingtan Village
R2	M	84	Resident, Meiling Village	G8	M	46	Management Committee of the Scenic Area, Nanxiong
R3	M	50	Resident, Meiling Village	G9	F	37	Management Committee of the Scenic Area, Nanxiong
R4	F	47	Resident, Lingtan Village	V1	F	24	Volunteer, Guangzhou
R5	F	52	Resident, Lingtan Village	V2	F	46	Volunteer, Guangzhou
R6	M	41	Resident, Lingtan Village	V3	M	22	Volunteer, Guangzhou
R7	F	49	Resident, Lingtan Village	V4	F	39	Volunteer, Nanxiong
R8	M	61	Resident, Lidong Village	V5	M	52	Volunteer, Nanxiong
R9	F	39	Resident, Lidong Village	V6	M	34	Volunteer, Guangzhou
R10	M	46	Resident, Lidong Village	T1	F	41	Tourist, Shaoguan
R11	M	49	Resident, Lingtan Village	T2	F	32	Tourist, Shenzhen
R12	F	46	Resident, Zhongzhan Village	T3	M	45	Tourist, Shenzhen
R13	M	50	Resident, Zhongzhan Village	T4	M	40	Tourist, Guangzhou
R14	M	49	Resident, Zhuji Village	T5	M	38	Tourist, Dongguan
R15	F	62	Resident, Jiaowan Village	T6	F	41	Tourist, Huizhou
R16	M	57	Resident, Congbei Village	T7	F	38	Tourist, Huizhou
R17	F	42	Resident, Congbei Village	T8	M	35	Tourist, Guangzhou
G1	M	40	Government staff, Tourism Sector	T9	M	54	Tourist, Shenzhen
G2	M	38	Village Committee, Meiling Village	T10	F	47	Tourist, Foshan
G3	F	42	Village Committee, Lingtan Village	T11	F	53	Tourist, Jiangxi
G4	M	29	Cadres Staying at Villages, Lingtan Village	T12	F	40	Tourist, Jiangxi
G5	M	64	Government staff, Tourism Sector (retired)	T13	M	25	Tourist, Shaoguan
G6	F	37	Village Committee, Lidong Village	T14	F	48	Tourist, Shaoguan

The analysis reveals the cultural experience and perception of various actors' production of the Meiguan Historical Trail space. It summarizes the various representations of culture in restoring and utilizing the Meiguan Historical Trail and the cultural practice behavior of each subject in the space. To ensure the comparability and scientific nature of research data, during the data collection process, researchers collected and analyzed literature, Nanxiong County records, policy texts, planning texts, and news reports related to the restoration and utilization of the Meiguan Historical Trail. Regarding the use of interview data in this article, one point deserves elaboration. Considering the need to summarize the changes to the Meiguan Historical Trail and the villages along it, the presentation of the interview results is predominantly not a format of direct quotes; more often, they are organically integrated into the narrative and analysis of the findings. This fits with Russell Hitchings and Alan Latham's conclusion that interviews are a major qualitative method of human geography, wherein indirect quotes are also one of the conventions [44].

4. The Cultural Value of LCH in the Government Planning Plans

4.1. Omission of Cultural Value

From the historical development, the excavation of the Meiguan Historical Trail is inextricably linked to the political and economic development of the Lingnan region. Since the opening of the Grand Canal in the Sui Dynasty, material exchanges between the north and the south have significantly changed in Chinese history. In addition, the economic and cultural exchanges became more frequent, especially in Guangzhou, a trading port with closer exchanges with the interior, making it necessary to open a significant transportation route connecting the south and the north in the Lingnan region. Since the Tang Dynasty (716 AD), the Meiguan Historical Trail, as a medium for trade, military, and cultural exchanges, has experienced the prosperous stage in the Ming and Qing Dynasties, the transition from prosperity to decline at the end of the Qing Dynasty, and the transformation of cultural and leisure functions in the modern period. Since the silence for more than 40 years, Meiguan Historical Trail has been protected from 1989 to 2010, but the protection planning of LCH is still at a relatively macro level. It has not explicitly covered specific cultural relics and monuments at all levels of the historical trail. The plans show that the local government did not realize the overall value of the Meiguan Historical Trail and the villages and cultural resources along it. However, they equated it with a common monolithic cultural heritage for tourism. Residents' recognition of local culture and sense of belonging is not strong.

We also know that cultural heritage needs to be repaired and protected, but the government lacks funds and does not pay special attention to it. The resources are all scattered, one here and one there. The value of a single point is not high, and tourism cannot be developed after it is repaired. It is not easy to apply for special funds. So, we kept it there and did not advance much. At most, it is the ones that are the focus of protection, the ones that are of higher value, and the others who are powerless. (G1)

The old houses in the past were useless and dilapidated. Other people have made money outside, and they have all built a new house, which is big, beautiful, and comfortable. (R5)

The protective actions before 2015 show that the fragmented resources of the Meiguan Historical Trail have weakened the local government's judgment on its cultural value. During this period, the cultural value of the Meiguan Historical Trail was limited to the Nanxiong Government level. It did not involve the cultural value of the South China Historical Trail at the Guangdong level. The ruins of villages and historical buildings that classify as linear have not been well restored and utilized. From the cognition of the local government and residents of places that classify as linear, the cultural value of the Meiguan Historical Trail is lacking, driven by the demand for modernization. Due to the temporary lack of necessary funding sources and scientific planning plans by local governments, the restoration and utilization of the Meiguan Historical Trail lack attention to the overall cultural value of LCH. The omission of cultural value caused the Meiguan Historical Trail to experience a long period of silence.

4.2. Weighting of Cultural Value

In China, economic, social, and cultural development mainly stems from guidance and support at the national level, especially in remote cultural heritage sites and poor villages [45]. As a spatial carrier of historical evolution, the South China Historical Trail shows the characteristics of the country's regional culture. It is an essential carrier for the integration and interaction of urban and rural economies [17]. Based on national strategies, such as rural revitalization and coordinated regional development, the restoration of the South China Historical Trail has carried new tasks and has become a political practice symbol for implementing these national strategies. Under the rendering of developmental doctrine words, such as "cultural heritage protection", "greenway construction", and "rural revitalization", the value condensed in the body of the Meiguan Historical Trail was separated and transformed. The modern function underwent a massive transformation through implementing policies at the grassroots level and investment attraction. The

Meiguan Historical Trail has gradually shown a way of rural revitalization, with the vital meaning of connecting the remains of old stations that classify as linear, historical villages and towns, cultural relics and monuments, and natural landscape resources to meet the needs of the public in modern life [11]. Figures 2 and 3 show the changes to the Meiguan Historical Trail.

Figure 2. Meiguan Historical Trail before the project. Source: the authors.

Figure 3. Meiguan Historical Trail after the project. Source: the authors.

The South China Historical Trail revitalization was carried out after comprehensive research and demonstration by experts and the government. The South China Historical Trail has essential value and significance for constructing a solid cultural province in Guangdong. Moreover, there are many cultural heritage resources scattered around the linear. A single point may be of little value, but it differs from stringing these points together with a unified theme. There are also many poor villages along the South China Historical Trail. Meiguan Historical Trail is not an exception. It is widely present in Guangdong Province. Guangdong's economy is uneven, with the wealthiest cities and poorest villages. Therefore, all revitalization and utilization are promoted based on the cultural heritage and cultural value of the South China Historical Trail. In 2016, the Government of Guangdong proposed to repair the South China Historical Trail, and the province's efforts were used to promote this matter. (V2)

The original function of the Meiguan Historical Trail in the linear space is as a land medium for north–south communication. The South China Historical Trail now shows the characteristics of the country's regional culture and is an essential carrier for the integration and interaction of urban and rural economies. The proposal for the revitalization and utilization project of the South China Historical Trail redistributes and weights the cultural value:

1. Cultural and ecological restoration transformed the historical trail and the village landscape along it into the initial linear landscape value, integrating it into the linear space of the entire province.

2. The restoration and utilization project of the South China Historical Trail strips the value of the Meiguan Historical Trail from a single resource. It is integrated into the entire South China Historical Trail. It is weighted and overlaid, and the value of the Meiguan Historical Trail is best presented in the form of cultural reproduction.
3. Part of the value of the historical trail was transferred to the community and tourists. Residents and tourists sensed the cultural value in their experience and practice and even felt they were the heritage owners [46].

After the start of the South China Historical Trail project, municipal governments at all levels have corresponding tasks to complete. There is exceptional funding support from provincial finance every year. The province has issued many standard documents, including protection and restoration guidelines, identification system design guidelines, protection and utilization master plans, and management and maintenance mechanism research. The provincial government has financial support, but there are also work requirements. The province has unified standards, and the restoration of every ancient road must be carried out following the requirements. It is not by temperament but by doing whatever you want. (G1)

As an essential demonstration section of the South China Historical Trail, the local government of the Meiguan Historical Trail, under the norms and guidance of various plans of the higher-level government, excavated cultural characteristics through various means. In addition to protecting cultural heritage, cultural production is realized more through activation and utilization. In the spatial reconstruction of LCH, local governments have played a vital role in the authoritative certification of cultural values [47]. Accordingly, specific spatial reconstruction activities are also embedded in the planning framework of higher-level governments for local governments [48]. The revitalization and utilization project of the South China Historical Trail represents the weighting and transfer of the cultural value of the Meiguan Historical Trail. The accompanying planning plans determine the content and standards of the spatial reconstruction and guide the practices. Figures 4 and 5 show the changes to the Lingtan Village along the Meiguan Historical Trail.

Figure 4. Lingtan Village before the project. Source: the authors.

Figure 5. Lingtan Village after the project. Source: the authors.

5. Cultural Practice in the Spatial Reconstruction of LCH

5.1. Government-Led Cultural Production

Restoring integrity is an essential practice in the spatial reconstruction of LCH. The cultural production of the Meiguan Historical Trail is not "produced out of thin air". The local government focuses on the repair and revitalization of the main body of the Meiguan Historical Trail and the village buildings that classify as linear. Based on the overall plan for the protection and utilization of the South China Historical Trail, the local government has adjusted the plan to meet the protection requirements and satisfy the market demand. Specifically, the local government has implanted the design of modern elements in the restoration of the historical trail, and its positioning has also been adjusted from the original "traffic route" to the "cultural route". In order to build the Meiguan Historical Trail into a cultural consumption space, the local government has implanted tourism, sports, festivals, and other elements based on restoration and connecting the cultural content and natural landscapes on the Meiguan Historical Trail.

The restoration of the Meiguan Historical Trail was conducted for sustainability. Our primary starting point is protection, so we restore as much as possible. Many roads of the Meiguan Historical Trail are incomplete. All of them are grass. What we see now is restored, and the materials are based on history and local stones. (V2)

Although historical materials provide an imaginary entity for the restoration of the South China Historical Trail to be copied, in the planners' view, this authenticity was constructed by them [49]. Regarding local image construction, the Meiguan Historical Trail relies on theme festivals to realize cultural representations, such as the Plum Blossom Festival, the Surname Culture Festival, and hiking activities. Local governments consciously make selective use of the culture of space and invent creatively to enrich the content and significance of culture with festival activities [50]. At the same time, the integrity at the core of the Meiguan Historical Trail culture is constantly emphasized. It is worth noting that modern cultural elements are not mechanically embedded in the spatial production of the Meiguan Historical Trail but are placed by local governments and planners. Furthermore, after being given cultural significance for consumption by tourists, the South China Historical Trail, with its surrounding villages, has also been branded with commercialized symbolic features [51].

The restored Meiguan Historical Trail is essentially embodied as a cultural product, and its commercial value lies in the tourism market. For example, a direct economic return from the Meiguan Historical Trail is tickets costing CNY 40 per person for the tourist attraction. The villages also enjoyed the dividends of tourism in the construction of living environments and income. In order to cope with the increasingly fierce competition between places, the government authorities have adopted local policies to enhance the "economic competitiveness of specific places, regions, or related scales" [11]. As a direct result, these authorities have consolidated the logic of profitability and economic growth within their political jurisdiction to create or restructure their territory, population, built environment, and competitive advantages of economic subjects [52]. Although the policy background is not the same, this theory has been confirmed in the practice of spatial reconstruction of the Meiguan Historical Trail. For example, each section of the Meiguan Historical Trail will be repaired following the unified standard of repairing the old as the old and maintaining the authenticity so that the LCH will consolidate its competitiveness in the tourism market. Therefore, this article echoes Brenner's argument [53] that local policies may try to "enhance local advantages in the division of consumption space by creating or strengthening localized infrastructure for tourism and leisure functions". In addition to being a commodity of the tourism industry, the South China Historical Trail also represents an important historical and cultural source in Guangdong.

The South China Historical Trail has witnessed the changes and development of the history and culture of Guangdong, which cannot be ignored. Without the South China Historical Trail, Guangdong's history would be inconsistent. The role of the South China Historical Trail is to *condense the culture of Guangdong. The culture of the Meiguan Historical Trail is an integral part of the South China Historical Trail and is Guangdong's historical and cultural accumulation. (G5)*

For the government, restoring the Meiguan Historical Trail can protect cultural heritages and connect resources that classify as linear to enhance the competitiveness of the villages in the tourism market through the construction of significance. In addition, the South China Historical Trail represents the long-established southern Guangdong culture. It has enhanced the sense of pride and identity of Guangdong, the Guangdong–Hong Kong–Macao Greater Bay Area, and other places. The connection between heritage sites and national pride is a symbolic means by which the local ruling elite interprets the culture and South China Historical Trail and national core. The Meiguan Historical Trail has provided tangible evidence of the prosperous economic exchanges between the north and the south in history. Through this symbolic connection, the local ruling elite hopes to revive the cultural heritage of the Meiguan Historical Trail and add meaning so that both residents and the tourism market can accept it. For this group, Meiguan Historical Trail is such a localization project that it is a booster for rural revitalization. It aims to portray the South China Historical Trail in a positive and even eye-catching image to attract more tourists and accelerate the development of villages along the route.

5.2. Cultural Identity of Local Residents

In the process of spatial reconstruction, the ecological mechanism of traditional culture and the cultural values of local subjects all play an essential role [54]. The cultural atmosphere represents regional culture, which is of great significance to the formation of the core attractiveness of tourist destinations and the deepening of the local identity of residents [55]. In the context of rural revitalization, LCH gives full play to its cultural advantages to drive the development of villages that classify as linear. It should be pointed out that in the process of spatial reconstruction, the culture of the Meiguan Historical Trail was re-recognized and produced by residents.

In the past, Lingtan Village was called "Mud Pool Village," with dilapidated houses and mud roads. Thanks to the Meiguan Historical Trail, the government has paid attention to us. After the transformation, life slowly got better. Now we can also attract some people to travel here and make some money by selling local specialties. We will not be embarrassed to talk about Lingtan Village to others. People outside envy us. (R11)

In addition to the expression of words, the residents' cultural identity with the spatial reconstruction of the Meiguan Historical Trail is also manifested in their direct participation in cultural production through business activities. Influenced by local history and culture, residents "invariably" have evident local cultural orientations when choosing business content, such as long cigarettes, Meiling goose king, and other commodities. These characteristic products are subjectively active by residents and an essential factor in the production and expression of Meiguan Historical Trail culture. On the one hand, Nanxiong has been a place where tobacco leaves have been produced since ancient times. Today, the villagers' homemade extended versions of earthen cigarettes are sold along the Meiguan Historical Trail and in ancient houses. Lengthened cigarettes have also become one of the local characteristic commodities. At the same time, the villages along the Meiguan Historical Trail have also developed the local dish Meiling Goose King into a specialty dish. The signs of Meiling Goose King can be seen everywhere, and it has become one of the iconic foods of Nanxiong. In addition, most tourist souvenirs are peripheral products with the theme of surnames, further strengthening Zhuji Ancient Lane's surname culture. The reconstruction of space has not only brought tourists but also brought tourism income to the place. The original poor village has become a bright and beautiful countryside. Local subjects participated in the planning and design process of the revitalization and utilization project of the Meiguan Historical Trail. With the benefits of tourism development, local culture has been re-recognized and produced by the locals. Under the government-led cultural production, the residents' active recognition and practice of the spatial reconstruction of the Meiguan Historical Trail in their consciousness reflect the cultural identity and cultural production in the spatial reconstruction of linear cultural heritage.

After the Meiguan Historical Trail began to develop tourism, the environment in the village became much better. Many old houses in the past were dangerous. The new house is spacious and beautiful and much more comfortable to live in. We hope tourism will improve so that there will be more tourists and income, and the children at home will be guaranteed to go to school. (R16)

5.3. Cultural Consumption of Tourists

Of course, the restoration and utilization of the Meiguan Historical Trail are culture-oriented. However, government publicity and marketing by residents will encourage tourists to consume culture here to achieve profitability. Therefore, the perception and experience of tourists have become a necessary reference basis for the government and residents to carry out spatial reconstruction [56,57]. Although tourists do not directly interfere in the spatial reconstruction of the Meiguan Historical Trail, the identity of cultural consumers makes them a member of the subject of power and participate in the cultural construction of the Meiguan Historical Trail in the form of a familiar presence.

In order to cater to the diversified cultural consumption needs of tourists, the Meiguan Historical Trail connects the surrounding greenways and integrates the resources of traditional villages that classify as linear. Based on diversified cultural resources, such as red culture, Guangfu culture, and Hakka culture, the Meiguan Historical Trail is combined with orienteering events, resulting in the Meiguan Historical Trail showing a situation where traditional culture and modern culture are mixed [58]. The multicultural cultural landscape has led to the negative cultural experience of some tourists.

I do not get an intense atmosphere of culture. However, the government has done much, from the changes in villages and the publicity columns. However, I can't feel any cultural heritage. The cultural atmosphere of Zhuji Ancient Lane is slightly better, mainly based on ancestral hall culture and surname culture. However, it feels like nothing is directly related to Meiguan Historical Trail. (T1)

Some tourists also believe that the cultural representation of the Meiguan Historical Trail has not been fully highlighted. In recent years, scholars have continuously reflected on the tendency of "cultural commercialization" and "commercialization" in the process of globalization. They have gradually realized that local culture can use individual reflection to fight against global cultural hegemony [59]. The local government tried highlighting the local advantages and used the Meiguan Historical Trail to package and develop all the resources that classify as linear. On the contrary, it led to a negative cultural experience for some tourists. On the contrary, various representations of the local culture are more popular and favored by tourists.

It feels like this is an ordinary road. It has not been fully developed, so it is not convenient to do anything. The experiential nature is not enough, just look at it, and it has gone. I feel that the culture has not been excavated much, and the experience is not very good. (T6)

The cultural experience needs of tourists are closely related to the activation and utilization of LCH, and the original cultural elements of local society are generally considered valuable. However, constructing a more attractive LCH requires injecting more current local culture and art [60]. If LCH is only restored, the lack of connection with tourism needs in its utilization may reduce it to an empty physical space, making it challenging to obtain the cultural identity of tourists and then lose the inherent motivation for sustainable development [40].

6. Conclusions and Discussion

6.1. Academic Implications

The aim of this article has been to further the understanding of LCH production as rural local policies through a focus on the process of reconstruction and interpretation in Meiguan Historical Trail. Based on the theory of spatial production, this paper critically examines how the Guangdong provincial government incorporates linear cultural heritage production into the regional policies formulated by the local government. At the same time, it also emphasizes the compliance of local residents to national efforts and the doubts of tourists to national efforts, further explaining the dynamics of heritage production. Along with the return process of authenticity, alienation, and the construction of heritage, the value and significance of LCH transcend themselves in the reconstruction [61,62]. From the perspective of the market logic of tourism development, the ancient bridges, fences, and other single resource units scattered in the villages along the Meiguan Historical Trail cannot achieve independent commercial value. In order to enhance local competitiveness in the tourism market, the government has made an alternative interpretation of the character of the dispersion of LCH, which represents a strong concatenation and local cultural pride. After officially recognizing this cultural value, revitalization, and utilization projects are advancing rapidly. This discovery confirms the argument of Winchester [63] that the landscape plays a leading role in the naturalization of the ideological system because "the landscape dominates in daily life and has a very tangible and visible material nature, making the things constructed by society seem to be the natural order of things". Therefore, the interpretation of cultural values in line with the ruling elite's interests means that "a process of intentional selection and connection provides historical and cultural recognition of the contemporary order" [11]. As Brenner suggested, the government authorities took action to mobilize space as productivity [53]. More specifically, LCH has been widely incorporated into China's rural political economy, and heritage products are produced through the government to "promote and encourage local development and employment growth" [35,64]. This function is similar to cultural heritage corridors [25]. Therefore, this article clarifies the critical role of linear cultural heritage production in China's rural political economy. Consistent with the recent research on the politics of heritage production in other cases, this research has shifted from the linear theorization of heritage as a means of control and exclusion to the more complex conceptualization of heritage as a dispute and negotiation of capital, memory, and identity.

Our research also contributes to expanding the analytical dimension of space production. This study further effectively links "culture" as a core element with the theory of space production and expands the cultural dimension [41]. The transformation of LCH and cultural consumption space is a contested terrain in which its production is continuously negotiated and reworked with the associated practices of dominance and resistance to transform place and space. Culture and power dominate the space production of the Meiguan Historical Trail, and the spatial practice of the current residents' re-identity has also added many grassroot elements of local culture to the Meiguan Historical Trail. However, the government's choice is not entirely undisputed. A series of cultural packaging decisions by the government caused part of the Meiguan Historical Trail to deviate from the market. The surface restoration and utilization made it difficult for some tourists to experience the local culture of LCH, and they questioned the project. The government-led practice of cultural production stems from the judgment of the overall cultural value of LCH, which is similar to the cultural route [17] and reflects the political appeal and cultural symbolism of "identity" at the local level. In addition, in the context of the spatial production of the "absolute power of discourse" of LCH, local subjects give feedback on actions that are "consistent" and that "agreed" and "conformed" with the government in terms of the relative lack of funds, discourse, and other resources. For tourists, what they care about is not cultural pride but the pleasure and depth of cultural experience. They affirm the efforts of the project but question the experience. Therefore, the spatial production of LCH produces "material manifestations of the operation of global capitalism found in specific locations" [65] and allows differences between different groups. At the same time, this paper expands the time dimension of space production and believes that the starting node of space production is not the moment when material changes occur. The concepts and plans related to space production will affect the direction and process of space reconstruction.

6.2. Managerial Implication

The enlightenment and significance of this article on practice also deserves elaboration. With the renewal of the heritage protection concept from a single site to the entire environment, people pay more and more attention to the integrity of LCH [6,27]. Therefore, balancing the relationship between comprehensive development and partial reuse has become an urgent problem, especially for large LCH [66]. The case of the Meiguan Historical Trail shows that LCH tourism is a feasible solution for the integration of culture and tourism. By deepening the understanding of this special heritage type, this study provides theoretical guidance for the existing large-scale heritage management and further policy adjustment. In addition, most of the early studies focused on LCH itself, but a few studies revealed the impact of the overall tourism utilization of LCH on residents and tourists that classify as linear. Supported by multidisciplinary theories and various methods, this study focuses on and attempts to analyze the response of the general public. As far as the global linear cultural heritage is concerned, the discipline and compliance state of "consistency" and "identification" presented by residents in the Meiguan Historical Trail case is universal. In fact, residents along the Meiguan Historical Trail show an optimistic attitude of "supporting tourism development", but they seem not to care about cultural pride, which shows the obvious difference between the local government and residents. Therefore, in the practice of global linear cultural heritage restoration and utilization, we should attach importance to the cultural identity of residents and guide residents that classify as linear to actively participate in the protection of cultural heritage and stimulate the subjectivity of residents. In the marketing and publicity of linear cultural heritage, we should pay attention to the cultural experience of tourists; strengthen the atmosphere of ancient post roads by relying on festival activities, such as Plum Blossom Festival and Surname Festival; and further promote cultural tourism consumption.

6.3. Suggestions for Further Research

The Meiguan Historical Trail case informs us about the trend of the restoration and utilization of the South China Historical Trail, which is distributed in a mesh in Guangdong with 202 roads, and covers 1320 villages within 5km that classify as linear. In order to meet the needs of cultural heritage protection and coordinated economic development, the restoration and utilization of the South China Historical Trail have shown the characteristics of political and economic functions under the guidance of culture. The spatial reconstruction of LCH reflects its connectable overall cultural value rather than the individual cultural value of a single resource [6]. It also reflects the vital role of cultural heritage production in China's rural political economy [11,25]. The project of utilization of the South China Historical Trail is not only a cultural heritage protection project but also a cultural symbol selection project. Therefore, future research can further investigate what the consequences could be of the government effects in the LCH and cultural aspects of the MHT once the surveyed residents are submissive to the government's efforts. In addition, the tourism development of the revitalization and utilization project of the South China Historical Trail still needs to be built, especially since the sense of identity representing regional cultural symbols has not been fully established in the market. Future research can use more in-depth scales, such as local identity, to further research and deepen the further discussion of tourists' response to the results of spatial reconstruction.

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Cultural Identity: A Case Study in The Celebration of the San Antonio De Padua (Lajas, Perú)

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Abstract: This study presented the first analytical experience of cultural changes in the Lajas population by analyzing their social perceptions and cultural manifestations. Moreover, an increase in the number of visitors and tourism generated new interactions that often have unknown impacts on a particular community and its people. A qualitative methodology consisting of observations and semi-structured interviews was employed to evaluate the evolution of customs during the celebration of Lajas population religious functions between 2003 and 2018. The study results revealed that in the town of Lajas, while the population recognized ways in which their customs have changed in recent decades, they were unable to determine whether or not such changes affected their cultural identity and the preservation of their cultural heritage. Further, on analyzing the obtained data and comparing it with the proposed theoretical framework, we observed a gap between social participation and public administration management, the transformation of the existing model to a centralized management control model, and the creation of an official identity. Hence, such observations are necessary to lay the foundation for future studies to avoid negative impacts and generate sustainable management strategies that would justify the effort in conserving cultural identity.

Keywords: cultural identity; heritage; popular religious festival; cultural change; Peru

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1. Introduction

Cultural identity is complex and can be defined in different ways, and in the current interaction context of globalization and technological development, where social interaction and sociocultural manifestations are in increasing evolution and are exposed in virtual environments, any social group can harbor multiple cultural identities [1]. Generally, a community's cultural identity is characterized by its beliefs, customs, values, and symbolic traditions of everyday life [2–6]. In this sense, traditions, due to their significant potential, are very important in sociocultural, economic, and political expressions in a territory [7]. Crouch [8] regarded nonrepresentative geography as the set of symbols, images, or metaphors that a group communicates as a part of its daily practices. For UNESCO [9], cultural identity is a concept derived from material and spiritual elements, inherited within a social group that represents a strong authenticity [10] and facilitates the understanding of a culture and increases the community's value. Therefore, cultural identity is a determining characteristic of a region; it encompasses its own specific features and contrasts different peoples' customs [11], alongside identifying the expressions that are the results of social interactions between different communities [12]. Hence, cultural manifestations will always constantly interact [13], change, and evolve.

This study was based on identifying and analyzing the evolution of some of the original elements that characterized the cultural identity of the Lajas people; in particular, cultural change will be determined by studying the San Antonio de Padua religious festival over the past 15 years.

In general, festive celebrations express important symbolic elements that are part of people's daily lives, and these elements aid in determining a social structure and the values that identify it [14]. In fact, studies on festive celebrations [15–17] reveal the cultural wealth of communities. Thus, by researching the transculturation process, we can identify the ways in which a given culture has transformed or the cultural elements that have survive [18]. This process involves reflecting on social behaviors and catalysts for cultural change from different perspectives such as social, economic, environmental, and technological. Festive celebrations in general, and religious ones in particular, are an expression of cultural identity and, according to Ramírez [18], are linked to preserving memories and those breaks that invent possible futures. In this sense, processes such as globalization, which include widely diverse components, including the demystification of many celebrations [19], compels us, as researchers, to identify their cultural originality [20,21].

In that sense, in Peru, in the communities of Saccacca-Paru Paru, Misminay, and Amaru in Cusco and Raqchi in Puno, the local inhabitants exhibit their ancestral practices through religious festivals and artistic expressions that distinguish them from each other in the rural space. These communities are the product. After interacting with tourists, they modify their heritage with the modernity that they bring [22], so that, after mutual learning experiences, they build their own personal identity, all of which are an expression that reflects the identity of the people, their way of learning, behavior, and self-identity that are constantly changing [23]. Likewise, the Festival of the Virgen de la Candelaria is the most important identifying reference of the inhabitants of Puno-Peru [24], along with Lake Titicaca, the offering to Pachamama, Alasitas, and Zampoñas [25]. The veneration of the Virgen de la Candelaria is widely spread across other cities' borders, such as Lima, Arequipa, and Tacna, where the residents of these cities live and teach their devotion in their communities [26].

This devotion to the Saints in Peru, in patron or religious festivities, fulfills several functions within the community: the first is the integration function of individuals, migrants, and locals, who live together for a common reason: to bring out the festivity; the second is to achieve prestige within the group, by assigning important roles to prominent figures within the town (residents recognized by the community or by economic solvency) and who organize and pay for part of the activities of the festival; and third, to achieve a "popular sacrament" where the people preserve a genuine sense of the festive [27].

The religious identity of a particular people is manifested through the established forms of organization and ethical norms about the divine. In addition, it influences a person's meaning of life, and their way of understanding and explaining their reality is characterized by the expressions of feelings, attitudes, and moods and by a set of symbolic elements, beliefs, and rites that build a spiritual value, especially at a time of religious celebration as is the case of the present study. [16,27,28]. A religious manifestation is part of a group and individual self-perception (constructed authenticity) found in a religious festival, in a specific space and time; it also adds value to the overall experience, and the participants identify with particular local expressions [29–31].

Lajas is a town located in the province of Chota, department of Cajamarca, in Peru's northern highlands. With agriculture and livestock being its traditional occupations, Lajas is surrounded by mountains, and the Chotano and Lajeño Rivers intersect in its territory, thereby providing water to about 11,093 inhabitants [32]. The Churucancha cultural site, the thermal and medicinal baths of Chancay, and its natural landscape are some of the town's main attractions.

The San Antonio de Padua Patron Saint Festival in Lajas-Cajamarca was first celebrated in the 19th century when the town was founded in 1856. María Rivasplata, one of the community's founders, gave up her land in exchange for a festival for San Antonio de Padua. The celebrations lasted for three days in July [33]. Currently, the festival lasts for six days since, in 2003, the local priest, Fernando Idrogo, decided to extend the celebration's duration.

The Lajas Festival consisted of three days of prayer to San Pedro. But, in 2003, more days and activities were included, sponsored mainly by representatives of the Catholic Church and a group of the faithful. In recent years, the festival has grown, and the local government, as well as other political agents, began to participate in the organization of less religious activities. The festival did not have a butler to manage this type of performance, this figure being more present in other types of minor festivities and in other districts of the area.

Since its inception, the San Antonio de Padua festival has been adapting to social changes, and new traditions are being developed that the population assumes as its own. Every year, this festival has been experiencing an increase in the number of attendees, primarily from the province of Chota and mostly from the nearby towns.

Therefore, the main objective of the study was to analyze the festival's evolution since 2003 when the celebrations of this festival were extended to six days; it is an exploratory and descriptive study of the past 15 years. Research was specifically conducted on the evolution of intangible cultural manifestations of certain customs related to religious practices, music, and gastronomy, and the social participation and perception of the celebration's development were analyzed. These aspects allowed us to expand the degree of knowledge about the cultural identity of Lajas through the San Antonio de Padua festival, thus facilitating more complete research on its evolution, impacts, and future effects.

Theoretical Framework

Currently, cultural manifestations are a determining factor in the social and economic development of many communities; therefore, managing these cultural assets is a fundamental part of understanding and preserving them. Management actions facilitate awareness of preserving a town's customs and can generate a balance between the value of local expressions and visitors' identity [12,34–36].

The conservation of a community's cultural and heritage expressions depends on numerous factors. One of the factors is the ways in which a community deals with the cultural changes produced by new experiences in different social spaces such as tourism [37]. In fact, culture and heritage are currently a form of sustainable local development, namely, social, economic, cultural, and environmental [38–41]. These relationships have evolved, and currently, several tourist destinations include this type of resource in their offerings through a diverse array of tourist products. Popular secular or religious festivals are also part of this offering and have become increasingly important as a resource due to the vast and different activities that are accessible to different segments of the population [42].

Religious celebrations are a part of the cultural tourism products offered, and therefore, according to García [43], they have a value-in-use, thereby generating opportunities for social exchanges and revitalizing the economy under the umbrella of a series of symbolic values that exist; these scenarios promote changes such as acculturation or transculturation.

Music and dance, as a cultural manifestation, express sensorial and jointly, a collective feeling that motivates an emotional psychophysiological reaction, which leads to living an experience of connection between the participants [6]. Its roots occur in specific cultural or social ecosystems [44,45], creating from this, socio-musical identities. In this sense, music founds a collective identity expressed in an image, in a dance, in speech, in an attitude towards things, this being a form of socialization, of self-definition that generates a sense of belonging [46]. Peruvian folk music expresses in its lyrics a symbol of social connection and its melody, harmony, and rhythm are a vehicle for the expression of identity. Thus, in the district of Lajas the Huayno, the norteña marinera and cumbia sanjuanera are known and valued.

Gastronomy, within a community, is an element of social construction that, associated with a particular context of the communities, reflects a trace of its identity through the form of cultivation, the selection of products, the typical dishes, and the forms to serve and consume [47]. Naturally, typical gastronomy not only encompasses the typical dishes and drinks of a locality, but it is also a tangible representation of its eating customs, traditions, techniques, and lifestyles of the people [48].

Cultural identity in relation to citizen participation shows a dialogue and interaction without social classes, where social resilience in the face of changes allows reorganization and maintenance of its structure and group identity [49]. Likewise, it helps to the decentralization of power in local authorities and connects the needs of the population with the public administration, since it allows knowing the local reality through the opinion of the population, which helps to make better decisions regarding public policies [50]. To achieve this, the population needs to empower itself through citizen science that promotes open and democratic knowledge within the reach of the population, who participate in part of the exercise of power, debates, and local management plans [51]. Likewise, citizen participation in festivities, cultural, musical, sports, and other activities may have economic benefits and is a great opportunity to promote tourism-related business [52].

In this sense, as a Latin American benchmark of intercultural analysis, Ortiz [53] proposed the theory of transculturation as a way of explaining the complex phenomena and transmutations experienced by the Cuban and Spanish cultures and other European arrivals. Ortiz [53] analyzed the changes in the economic, institutional, ethical, religious, linguistic, and psychological aspects of life in Cuba and described transculturation as the result of different phases of the transitional process from one culture to another, thus consequently giving rise to the creation of new cultural phenomena. Transculturation, as a concept, does not imply that a certain culture is inclined toward another, but instead, it implies the transfer between two active cultures that mutually contribute, thereby supporting and cooperating toward a new reality of civilization (Malinowski as cited in Ortiz [53–55].

García, as cited in Côté [56], called "hybridization" the sociocultural process in which separate social structures combine to create new structures that bear no resemblance to the former one because they are also hybrids.

Croucher and Kramer [57] propose the theory of cultural fusion, where human beings, when adapting to a new environment and coming from a different one, maintain a dynamic of interaction that allows them to decide what to take from a new culture, what to change, what to maintain, so from this intercultural decision process, a cultural fusion is born, where each society is the consequence of a set of subcultures open to change and in constant social adaptation. Let us also consider communication, technology, and the systemic migration [58], among other factors that contribute to social interaction. This theory maintains three conditions: socialization with the new culture, dependence on the dominant culture/environment, and the existence of communication between both cultures. Previously, Le Bon [59] in his mass psychology theory mentioned that when an individual is related to a different social group, he adopts some characteristics of the new group and of the environment he has entered. [60].

Likewise, it is worth noting the cultural theory and the model of power relations of Favre, Swedlow, and Verweij [61] who establish that power is based on culture, formed from social action, and where the sociocultural structure is reflected in public bodies and is commonly accepted by society itself.

All these approaches that try to explain the phenomenon of cultural exchange are the result of a complex network of relationships between different actors who are involved in one of the scenarios generated by celebrating a religious holiday such as residents, tourists, and public administrators, as in our case study. The relationship is multidimensional, and the results of their study analysis are uncertain because they depend on the interests of each group. Fuller [62] confronted this problem by focusing on defining the characteristics of the receiving community and then analyzing elements such as actors and their roles, the standardization of cultural heritage, and culture or conflicts in the community.

2. Materials and Methods

The methodology used in this study is based on the traditional qualitative techniques of the social sciences. In this sense, semi-structured interviews and documentary analysis were used. The type of sampling used was non-probability and convenience sampling (Kinnear and Taylor, 1998). In this sense, the selection of the key agents was determined by the degree of involvement, accessibility, and participation in the organization of the festivity and its visitors. Our study was exploratory and, therefore, preliminary, in order to increase the knowledge on the subject that concerns us in this work.

The research team has chosen this period of time, since it is from 2003 that the greatest interference of the municipality in the organization of the festival was identified, identifying progressive changes from the base date.

In the document analysis, analyzing texts, photographs, videos, and images related to the festival, which we were able to access, was essential, spanning from 2003 to 2018.

The analysis of results has followed the process of triangulation and coding of information through phrased codes and has considered the principle of information saturation, in addition to the technique of underlining and the hierarchy of colors.

In July 2018, interviews were conducted during the festival. The key agents selected for our study formed a sample of the inhabitants, the visitors, and the representatives of the sectors related to organizing the festival, such as the mayor or the parish priest and the representatives of the religious and civic committees.

We determined the diverse factors related to religious activities, clothing, entertainment, music, and gastronomy for data collection. All these factors were cultural manifestations that could be more easily converted into consumer goods and, at the same time, represent a clear expression of the community's cultural identity, thus providing us with the evidence of the evolution and sociocultural modernization. Community perception and participation were also recorded during the interviews conducted in writing and through videos. Further, the sample of key population agents was organized to set up semi-structured interviews, and a total of 43 people were interviewed. Age groups and the number of times the religious festivity of Lajas was attended have been considered, so the participants have been part of the process of cultural identity in Lajas (Table 1). The age groups are as follows.

Table 1. People interviewed during the celebration San Antonio de Padua festival in July 2018. Source: Created by the author, 2018.

Key Sectors and Agents	Sample (No. of Interviews)	Age	N° Veces en Festival Lajas
Young residents	4	20–25	10
Adult residents	6	40–60	20
Festival entertainers	2	40–50	8
Photographers	2	35–50	8
Bakers	3	30–60	15
Cooks	5	25–60	15
Bartenders	3	25–45	5
Civil and religious authorities	8	25–65	15
Visitors	10	25–55	4

3. Results

The study identified a clear evolution and transformation of the cultural manifestations in Lajas between 2003 and 2018. The most lucid aspects included changes in clothing (Figures 1 and 2), increased entertainment activities to meet the demand of those attending the celebration, the introduction of some gastronomic products, outsourcing music, and lesser attendees at the religious events. The increase in the number of visitors, their demands, and contact with locals are some of the reasons of the cultural changes that were observed.

Figure 1. Visitors and locals from Lajas in 2003 during the celebration.

Figure 2. Visitors and locals from Lajas in 2018 during the celebration.

While the use of traditional clothing (hat, poncho, and belt) is still preserved, particularly for holidays, competitions, and local public events, it has been replaced by other modern garments. In the past 15 years, the Lajas celebration has increased entertainment activities (Motocard competition, Miss Lajas Beauty Queen—rural queen (Figure 3)—music band competitions, bullfights, etc.) as opposed to more traditional activities such as the mad cow or jester bullfights.

Figure 3. Rural beauty queen competition in traditional dress (2013).

<< I used to wear the hat, but not anymore. I stopped using it when I was young >> S1

<< When the festival was just beginning and in my youth, I used to always attend the processions, but over time he stopped going . . . >> S9

<<It has always been a fun and an excuse to celebrate >> S4

<<Yes, it helps the identity of Lajeña and the rapprochement of the population towards the Patron Saint . . . >> S14

In terms of gastronomy, typical local dishes are the best sellers at the celebrations, although an evolution is also noted as other types of products are introduced. For example, compared to alcoholic beverages such as chicha de jora, warinaque, or sugar cane liquor, beer and soda are also widely available. The same is true with respect to kitchen utensils, traditionally made with clay, are replaced with aluminum tools. Gastronomy is understood as an expression that unites and generates feeling and identity because behind each typical dish that is prepared, there are a series of cultural manifestations such as the preparation methods, supplies, ways of consuming, and serving (Figure 4) [47]. In these activities, each participant has a role, a skill, and together with other symbolic and sensory elements, each participant ensures that the difference between the country and city cuisine is noticeable; the transformation of the tangible and useful activities impacts techniques and lifestyles; for example, eating out more during the celebrations [48].

(**a**) (**b**)

Figure 4. (**a**) The first image shows local people killing a pig (image 4). (**b**) shows the same process to cook the pork.

<<I believe that gastronomy unites the family, during the festival, the residents try to show off with the best typical dishes on their tables . . . >> S11

<<There are several [typical dishes] such as guinea pig with potatoes, chicharrón with cancha, and chiuche with milk. And to drink they always drink the chicha de Jora, the soft drink>> S6

<<I usually prepare the dishes the same way my mother-in-law taught me . . . >> S11

<<I always cook, my mom taught me>> S3

<<Yes, I usually have my hidden secrets that my mother-in-law gave me>> S11

<<I have always used the pots and wooden sticks, but the pots have changed because there is no patience to cook with firewood>> S12

<<Yes, in fact, almost all year round, our dishes are based on Lajeño products and rice, which is one of the few products that are brought from the coast>> S15

In terms of music, between 2003 and 2005, the most popular traditional music genres were the yaravi, huayno, and marinera (Figure 5) played by local groups.

Figure 5. Northern Marinera, dance folk (2012).

The music in Lajas between 2003 and 2005 included huayno (Figure 6) and local rhythms with percussion and wind instruments. Local groups played musical rhythms without lyrics, sometimes accompanied by clapping and whistling. Their members wore traditional clothing at festivals in Lajas, such as ponchos, hats, and belts.

Figure 6. Huayno, dance folk. (2003).

Commencing in 2006, after participation by the invited musical groups, with increasingly modern instruments and equipment, better sound, and popular lyrics, nationally recognized songs began to dominate, thus leading to a change in the preferences in the town of Lajas, along with increased attendance. In fact, beginning in 2006, musical groups from other cities were hired, thereby introducing other genres such as cumbia or sanjuanera music, with Colombian and Ecuadorian influences. Like gastronomy, traditional genres are a part of a cultural heritage and social cohesion [6,17,63]. Therefore, their loss may risk the social structure of Lajas, which may see their collective identity compromised [45,46,64]. Music and dance in Lajas are the product of a cultural fusion where the inhabitants within this dynamic of social interaction with other cultures have decided what to take, keep, or change, considering the rhythm of socialization with external cultures, their dependence on power, and the intensity of communication between them [57].

The level and mode of the population's participation in religious activities have also evolved. Some ceremonies such as baptisms and weddings increase during the celebrations. While the religious spaces have not undergone changes, the number of people interested in these celebrations has decreased compared with an increase in those only interested in entertainment.

Religion as a part of the cultural identity in Lajas is observed in the devotion to San Antonio de Padua, particularly in adults and seniors who also, while in the minority, maintain close ties with the church outside the celebrations. The San Antonio de Padua festival is held in religious spaces that are considered sacred, such as churches, chapels, or areas designated to worship San Antonio wherein there are no changes in terms of symbolism, images, songs, and rituals such as marriages and baptisms. However, since 2011, a decrease in the congregation was identified, particularly regarding the attendance of young people at church and scheduled religious events, while popular festivals and recreational activities are more popular. While this central aspect plays a fundamental role in the festival, religious traditions are shared through family heritage and this cultural manifestation is lived passionately by those who practice it within their own space and time [29]. The community's current expression has been built up on this aspect [30,31], in addition to the values developed in the Lajas community as a part of its sociocultural structure [14].

> <<I manifest my faith by going to mass and praying for my family. Also, I attend the religious activities that I am invited to, when there are baptisms or marriages and to make the rosary in the Church. >> S6

> <<I go to mass and light my candles to Saint Anthony of Padua in the church>> S11

> <<Well, with my family I go to mass and sometimes to the processions. Those who mostly go to mass are adults. >> S6

Participation from the population is very important in all the above-mentioned activities. Both among parish and civic groups, the San Antonio de Padua festival has been determined based on the community's decisions through its representatives. In 2009, however, the festival began to be exclusively organized by a municipal committee, which designs and establishes the festival's program, along with the church, thus not involving the population. In fact, since the festival's inception, the population has been directly involved in religious and cultural activities. While this was still the working methodology in 2003, the progressive changes identified in the festival's organization have made the residents resemble more spectators than organizers. In this sense, the municipality's responsibilities increase as a managing body that undertakes the administrative roles, thereby controlling the activities with economic benefits and an opportunity to enact and implement tourism-related policies [52]; these celebrations thus act as an identifying trait of Lajas within the town's entertainment and tourism activities. Thus, for example, until 2013, the arena was made of wood and built by the inhabitants of Lajas themselves. As visitors increased, the arena was built with cement and was built by the local government.

> <<I have not participated, because there is no custom and the contestants are in charge of public institutions and organizations such as the glass of milk of the communities. >> S10

> <<The residents don't take care of that, the municipality has a group of people who organize the party every year. >> S11

> <<Yes, we come to parade with our banner and our funds>> S2}

As a result of these policies, we must address the population's loss of interest and knowledge in managing and conserving their cultural assets, thus leaving it in the hands of the public administration [65]. Cultural identity and citizen participation demonstrate a dialog and interaction without social classes where social resilience in the face of change allows social structure and group identity to be reorganized and maintained [49]; in addition, this helps decentralize power among local authorities and connects the population's requirements to the public administration, as it fosters an understanding of the local reality through the population's opinion, thereby facilitating better decision-making when formulating public policies [50].

4. Conclusions

This study revealed several interesting issues. Moreover, two perspectives can be accepted as the most important: on the one hand, the evidence of cultural change in natural, dynamic, and evolutionary ways [66] and, on the other hand, the impacts of that change depending on the speed of its development, which was swift in our study, and the risk of losing the community's identity or of the community's cultural assets not being preserved that this aspect implies. However, there is a clear need to conduct an in-depth study to identify exactly what assets would comprise the Lajas cultural heritage and the opportunity to establish shared management with the municipality.

During the religious San Antonio de Padua celebrations, progressive interaction between the residents and the visitors is seen, which has resulted in some changes. In 2003, a large part of the population attended the festival for religious purposes, dressed in traditional local clothing, and the visitors' presence was less. However, the increased entertainment activities and the number of outsiders and the continuous influence of the external subcultures [16,22] led to frequent encounters and cultural changes [60]. Social interactions during the San Antonio celebrations reflect cultural manifestations that are changing as the community builds its own interindividual and collective identity models within its territory [7,12,13,23,39,57,60]. The population of Lajas is redesigning and creating its own celebration style, and this sociocultural process where social structures (residents versus other subcultures) combine to create new hybrid structures (García cited in Côté [56]). We may be facing a trend, i.e., inclining toward new forms of local expressions but with less of its own elements (or new elements of their own) that identify them, thus breaking the balance that must exist between valuing local elements and knowing how to interact with the external elements [12,34,36,39].

For example, with music, when a community identifies itself with local melodies, harmonies, and rhythms with their common and specific features [11,17] and, at the same time, accepts the blend of modern musical rhythms (regardless of whether traditional music is intended for cultural, religious, civic, or celebratory events and modern music is accepted for celebrations and fun), these aspects already reflect that, as a community, they are open to the possibility of adapting and building their own cultural identity in their territory through constant communication and social, cultural interdependence, etc. As Heisey [1] mentioned, cultural identity can even be globalized within a local context, and something similar occurs with religious identity, which, while it expresses beliefs and is established around different forms of organization and ethical norms, also includes more psychological aspects such as a community's mindset, in addition to an individual's mindset [16,27,28]. These remaining customs would affect the loss and transformation of the very spaces built to celebrate these religious activities, further affecting their authenticity [30,31,67].

This current reality, as Le bon [59] indicated, is the product of social adaptation to visitors' customs (a new influential social group), which are influenced by the atmosphere present during the festival.

As a future proposal, we must analyze ways in which the population accepts these changes. Answering this question will thus enable us to make proposals to manage Lajas resources. The progressive changes in the San Antonio's Lajas celebrations by municipal authorities (while these authorities are a part of the society and are an accepted and endorsed reflection by it as mentioned by Favre, Swedlow, and Verweij [61]) are creating new types of structure and power relations aimed in all probability to control and project an institutional image of the community.

The recent breakdown process, which has distanced the population from organizing and making decisions on the celebrations, should be reversed, and the population should be involved in the democratic municipal decisions. These aspects will help connect the people's demands to their representatives to improve joint decision-making [50,51]. To achieve this, the population needs to once again assume responsibility for promoting transparency within the reach of the population that participates in exercising power in the local management discussions and plans [51] through dialog and interaction without social classes, thereby enabling local communities to value themselves and be resilient to change their structure and identity as a social group and thus be able to organize themselves despite changes over time [49].

Finally, with a cultural celebration, it is important that people have knowledge and awareness of traditional events that have been discontinued or changed. Each person must understand and be aware of the importance of cultural heritage [24]. Cultural heritage is a part of the individual, national, regional, and local identities. It is also essential to understand the historical past and the fragility of intangible cultural heritage. Thus, knowledge begins with the criteria from each person or agent who intervenes in local development, being perceptible and realistic, and knowing their physical environment (Hoffman and Prakash as cited in Jansen [68]). This aspect would help to avoid indifferent behaviors toward conserving cultural heritage. The interviews conducted for this study demonstrate that the population is still aware of the changes in the celebrations in Lajas as a result of cultural and entertainment activities that have occurred over the past 15 years, as a part of the local management, the interaction between cultures from its own environment, recognizing changes in music, or attendance at religious events. Therefore, instead of focusing on managing the celebration in terms of increasing the gap, emphasis should be placed on sensitizing the local population on using and managing its resources.

By adopting different cultural expressions, the people of Lajas change and adapt because a transitive process (transculturation) from one culture to another, thus creating new cultural phenomena [53]. They are aware of changes in their cultural expressions [20], and it is possible they will enjoy them. They know that with some scheduled activities, their social interactions are strengthened, particularly where they can express their musical, gastronomic, and religious traditions. This is part of the premises of the study by Morley et al. [13], a context where cultural manifestations are in constant interaction and constant change and evolution. However, this requires a more in-depth study of social perception to help us understand what is the real impact of the cultural change that we have observed in this exploratory study, including variables with which we can measure whether or not there is discontent among the population. The result would probably give us non-balanced scenarios on which to act and provide solutions.

These expressions are a part of their authentic intangible heritage [69]. It is necessary to analyze their past as a collective memory to date [21]. To achieve this, the population needs to participate in the democratic management channels and once again participate in this exercise of transparency in the local management [51,70,71].

Clearly, Lajas is attracting a greater number of visitors from its nearby territories. This aspect certainly requires local management strategies to be sought, which safeguard and boost its traditions as a resource. In-depth research on its assets also needs to be conducted to best adapt to modernity and economic knowledge of the environment that shows economic potential as a resource in the town's growing demand for entertainment. Studying the celebrations undoubtedly represents a starting point to reflect on the identity of the town of Lajas. It also establishes the basis for presenting management alternatives and appropriate transmission of traditions, in addition to researching potential visitors and the benefits for the entire community.

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Article

Modelling and Assessing Sustainable Urban Regeneration for Historic Urban Quarters via Analytical Hierarchy Process

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Abstract: The push for urban development and the rapid increase in population have left many historic urban cores vulnerable and subject to deterioration. SDG-11 is often mentioned as the goal in UNDP regeneration, revitalization, and preservation projects regarding historic urban sites around the globe. The goal emphasizes 10 targets that are complex in nature and require closer inspection regarding their interconnectedness when being utilized in real-world scenarios. The current study explores the complexities of the decision-making process in planning urban regeneration projects concerning targets of SDG-11. The study uses a Multi-Criteria Evaluation (MCE) method to investigate how and to what significance the targeted criteria were used in planning for two UNDP urban regeneration project zones in Cyprus. These cases have a complex cultural and socio-political dynamic and pose high contextual significance for the region; therefore, many of these targets are critical in achieving more sustainable regeneration projects. The data collection was done by critically examining the projects' documentation and conducting interviews with experts involved in the two projects. The data is controlled for internal consistency and anomalies. The study makes its case by comparing the different approaches implemented in these two projects and how effective they were in achieving SDG-11 targets.

Keywords: urban historic tissue; MCE; AHP; sustainable urban regeneration; SDG-11; UNDP; historic urban tissue; urban design; urban decision-making

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1. Introduction

The increasing population of the world and the influx of people into the cities make them central in planning for the future of humanity [1,2]. The United Nations proposed 17 goals within the framework of Agenda 2030 to make the development process more sustainable in the future [3]. Goal 11, perhaps the most spatial among these, directly targets various dimensions of cities. This goal aims to make cities more resilient, inclusive, safe, environmentally friendly, and protective of their heritage [4]. Nevertheless, keeping the balance between sustainable development and the preservation of heritage is a challenging endeavor that requires innovative methodological approaches capable of addressing the multifaceted nature of the problem from both perspectives [5].

The SDGs are often interconnected and cannot be achieved individually. The goals have an air of abstraction for the most part and lack an empirical action plan. They are often perceived as general guidelines or directions to move toward [6]. It seems that having a standardized metric to evaluate the success rate of moving toward the SDGs should be considered [7]. SDGs are general guidelines; thus, a significant problem associated with them is the lack of empirical solutions or, rather, ambiguities in how empirical solutions at a local scale can be achieved.

The influx of population makes planning for accommodation critical in urban settlements [8]; this often happens in three forms: new residential units, regeneration of existing urban tissue, or informal settlements. In this regard, people's participation is an essential dimension of urban regeneration planning and policymaking [9]. Successful urban regeneration requires a balance between development and preservation [10]. Valencia et al. [11] state that "political will, coherent governance, and strong formal partnerships between the public sector, private sector, and civil society actors are key ingredients in achieving goals such as the SDGs." Bottom-up approaches that take into account the local residents' views and community-based frameworks are essential for sustainable and healthy regeneration practices [12]. The success of SDGs is dependent on the locality of their implementation strategies and how they affect the everyday lives of people [13]. This is especially critical as the vulnerable residential population is often most affected by regeneration plans that might have been designed with clear sustainability goals but without considering their needs [14]. The strive for sustainable development must not become a burden on lower social strata; instead, it needs to involve those people in the decision-making process [12].

Although Goal 11 targets cities and their attributes, the scholarly literature seems to be lacking in terms of addressing the interdisciplinary nature of urban regeneration with regard to the goal. It is evident that while tangible dimensions such as carbon emissions, materials, and climate have been thoroughly investigated [15], bottom-up urban design practices and the intrinsic socio-spatial quality of urban spaces seem not to be well defined within the framework of this goal. Many of these dimensions have been studied in urban design for decades outside the framework of SDGs, but moving toward seeing urban design frameworks through the lens of SDGs seems to be an inevitable necessity. The current paper focuses on the regeneration of historic urban quarters concerning Goal 11. The paper addresses the shortcomings of Goal 11 in providing tangible guidelines for the reality of urban design and planning practices. Furthermore, the relationship between local stakeholders and other institutional bodies is not well defined in Goal 11. The paper does not aim to address all indicators of Goal 11 targets, but rather explores contextual circumstances that might not fit within the overgeneralization of Goal 11 by including different involved parties. This process is conducted by superimposing the data associated with different targets and is often difficult to overlap. Therefore, the study aimed to utilize a Multi-Criteria Evaluation (AHP in this case) suitable for exploring a goal while addressing a multitude of data sources.

2. Material and Methods

Sustainable urban regeneration (SUR) is an intricate task for real-world project management and implementation. SDG-11 further adds to these complexities by introducing numerous long and short-term targets. Therefore, it seems critical to divide the goal into manageable criteria and sub-criteria relevant to the circumstances of the site and in line with the existing body of literature. Therefore, SUR can benefit from utilizing multi-criteria evaluation processes capable of addressing its natural intricacies. Additionally, this multi-criteria evaluation should be adopted for SDG-11 and targets historic urban quarters. Different case studies and literature reviews were realized, and criteria and sub-criteria packages were matched with targets (see Figure 1). Moreover, the lack of institutional transparency and urban data is one of the biggest obstacles when aiming for SDGs [16]; this is particularly problematic in less developed regions that are more in need of such approaches.

Urban regeneration programs are not mere spatial or physical interventions; they require the involvement of many different layers of data (e.g., social, cultural, economic, and historic). Furthermore, they require both top-down and bottom-up participation [17]. Accordingly, selecting a methodological approach that can receive input from different sources is critical. Multi-Criteria Evaluation (MCE) methods are strong tools in urban planning and regeneration, especially when the involvement of different parties, stakeholders, and data layers is required [18,19]. Utilization of MCE methods in approaching SDGs can potentially create a more comprehensive and successful empirical workflow [20]. MCE can be implemented in SUR to better understand the weights and priorities of intervening criteria, especially when future planning requires active modification or when the transformation of local contextual attributes transforms the plan [21]. The novelty of the study is exploring a new approach by using AHP for SDG-11 goals and targets, constructing a hierarchy for modelling, and measuring the sustainability level of urban regeneration activities within historical and cultural urban environments (see Figure 2).

11 SUSTAINABLE CITIES AND COMMUNITIES	11.1	Adequate, safe and affordable housing and basic services
	11.2	Safe, affordable, inclusive and sustainable transport systems
	11.3	Sustainable urbanization/settlement, planning and management
	11.4	Protect and safeguard the world's cultural and natural heritage
	11.5	Resiliency against natural disasters, protecting the poor and people in vulnerable situations
	11.6	Reduce the adverse per capita environmental impact of cities, waste management
	11.7	Provide universal access to safe, inclusive and accessible, green and public spaces
	11.a	Economic, social and environmental links between urban, peri-urban and rural areas
	11.b	Increase the number of resilient and sustainable cities/ human settlements
	11.c	Support least developed countries

Figure 1. United Nations' Sustainable Development Goals.

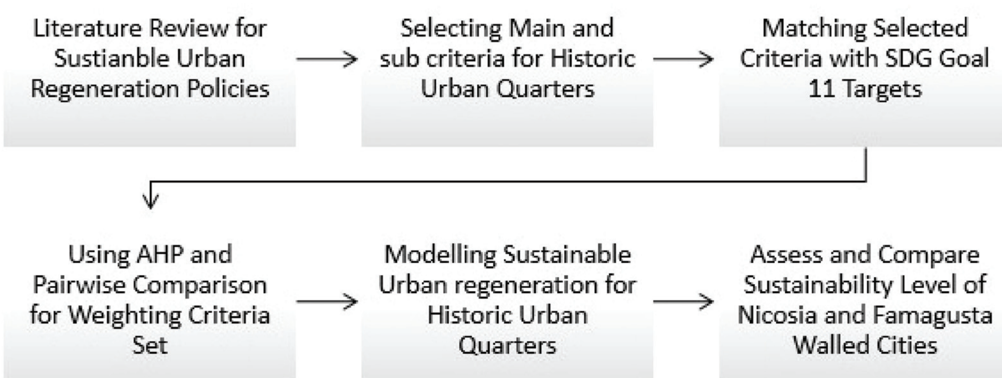


Figure 2. The framework of the paper.

Although SDG-11 has been used at the neighborhood level [22,23], urban regeneration policies and activities were not investigated within the SDG targets. The overlaying of different opinions and data layers generated by different parties is also a nuance of the current study.

2.1. Multi-Criteria Evaluation (MCE)

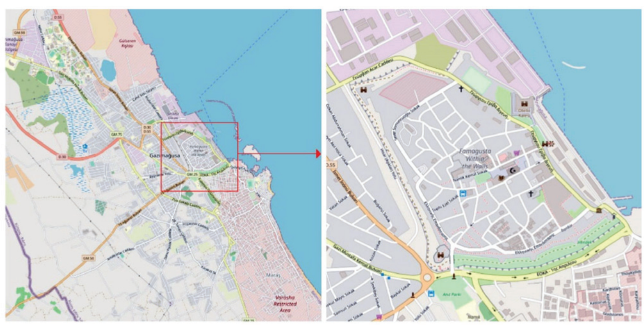
Multi-criteria evaluation methods (also known as multiple-criteria decision-making (MCDM)) are a set of methods designed to provide a logical workflow for decision-making when there are numerous (sometimes even conflicting) influential criteria [24]. MCE makes the process of decision-making in addressing problems of high complexity more informed and explicit [25,26].

When complex interconnected factors are present, the integration of MCE methods within the GIS workflow allows for more comprehensive decision-making [27–29]. The implication of MCE methods for urban regeneration and decision-making has a strong precedent in the literature [30–32], and this is more evident for sites of cultural heritage [33–35]. The Analytic Hierarchy Process (AHP) is among the most utilized MCE methods, first introduced by Saaty. The model is constructed by defining a goal that aims to select the best alternatives from a set of possible outcomes, followed by identifying criteria and possible sub-criteria. All criteria are then compared against one another using a pairwise matrix. Weighted criteria are then cross-referenced with the alternatives [36]. The pairwise comparison is usually done via a survey, but it can be achieved via other means of data analysis. The utilization of GIS in AHP modelling has been gaining traction and showing promising results [37,38]. Using GIS to support the weighing criteria is particularly useful in large urban settings due to the sheer number of influential criteria [39]. What is more, the fact-based nature of GIS might improve some shortcomings of surveys, such as a lack of consensus among experts or addressing a large number of evaluation criteria [40].

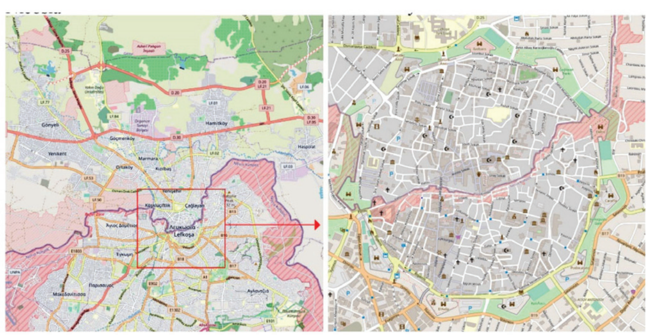
The process of conducting AHP analyses is often performed in five steps: setting up a goal, criteria, or sub-criteria, and an alternative, pair-wise comparison of criteria or sub-criteria with respect to the goal; constructing a comparison matrix; analyzing the weight of variables derived from the comparison matrix; and checking for potential inconsistencies via the measure of Consistency Ratio (CR). CR is calculated by using the Consistency Index/Random Index (CR: for more details, consult [41–43]).

2.2. Study Area

The paper explores two case studies: the walled city of Famagusta (also known as Gazimağusa, Figure 3a) and the walled city of Nicosia (also known as Lefkoşa, Figure 3b). Both cities have rich historic tissue, a large portion of which is located within the boundaries of the historic fortifications.



(**a**)



(**b**)

Figure 3. The city and walled city of Famagusta (**a**); The city and walled city of Nicosia (**b**).

2.2.1. Famagusta

The growth of Famagusta has been influenced by a variety of social, economic, and cultural intervening factors. The conflict of 1974, which bordered a significant part of the city, and the establishment of the Eastern Mediterranean University motivated the growth of the city toward the university campus and away from the walled city [44,45]; these circumstances have left the walled city less connected to the rest of the urban grid and prone to deterioration [46]. Original regeneration strategies proposed for the historic walled city followed the traditional sustainability triad of economic, social, and environmental factors [44,47]. Nevertheless, the integration of Agenda 2030 and the SDGs has not been fully explored in these renewal processes.

2.2.2. Nicosia

The walled city of Nicosia, similarly, has a rich history and has evolved and expanded over time [48]. Similar to Famagusta, the city has been divided after the conflict of 1974, with the buffer zone (or green line) cutting through the middle of the historic walled city. Nevertheless, the city has a master plan that was produced by both sides after 1977 [49] and finalized in 1981 as a conjoined official document [50]. Preservation, regeneration, and rehabilitation of historic tissue were central to the development of the Nicosia master plan, taking into account the complex intricacies of the two parts' economic, political, and cultural divides [51]. According to Tsolaki et al. [52], the Nicosia master plan regards regeneration strategies aiming to achieve social, economic, and architectural objectives. Although the master plan is a great undertaking, it has some shortcomings in considering administrative, environmental, and local stakeholders.

2.3. Selection of Criteria/Alternatives

The current study explores the multidimensional complexity of establishing a comprehensive practice for sustainable urban regeneration in areas with historic tissue. Accordingly, the goal of the study was to determine a more successful site in terms of "sustainable urban regeneration in historic urban quarters." The alternatives in this study refer to the two cases, the walled cities of Nicosia (northern section) and Famagusta, respectively.

Selection of the criteria and sub-criteria is often conducted by addressing the relevant body of literature and the circumstances of the sites [53]. There exist numerous approaches regarding the selection of criteria concerning the preservation and regeneration of historic environments [5,54–56]. The current study approached the topic from the main criteria for sustainable development (economic, social, and environmental); the administrative/legal dimension was added later because it has a significant contextual impact on how the other three dimensions can be realistically implemented [57,58]. The selection process of the associated sub-criteria was motivated first by the targets of SDG-11, the existing literature, and contextual circumstances of the site (see Figure 4). Each sub-criterion is corresponding to one of the targets of Goal 11. Targets 11.b and 11.c are not included due to their international scope that cannot be addressed within the scale of the current case studies.

2.4. Evaluation of Criteria Weights

After the criteria are set, implementing pairwise comparisons with experts related to the topic is required. Experts from town planning, municipalities, antiquities, universities, and chambers were selected to fill the comparison tables for the main and sub-criteria. The target group included architects, urban planners, academicians, and managers, who compared the given criteria by using the model proposed by Saaty [26]. The weights were calculated for each criterion (Table 1). Consistency Ratio (CR) values were also controlled for each comparison and are within the acceptable threshold (<0.05).

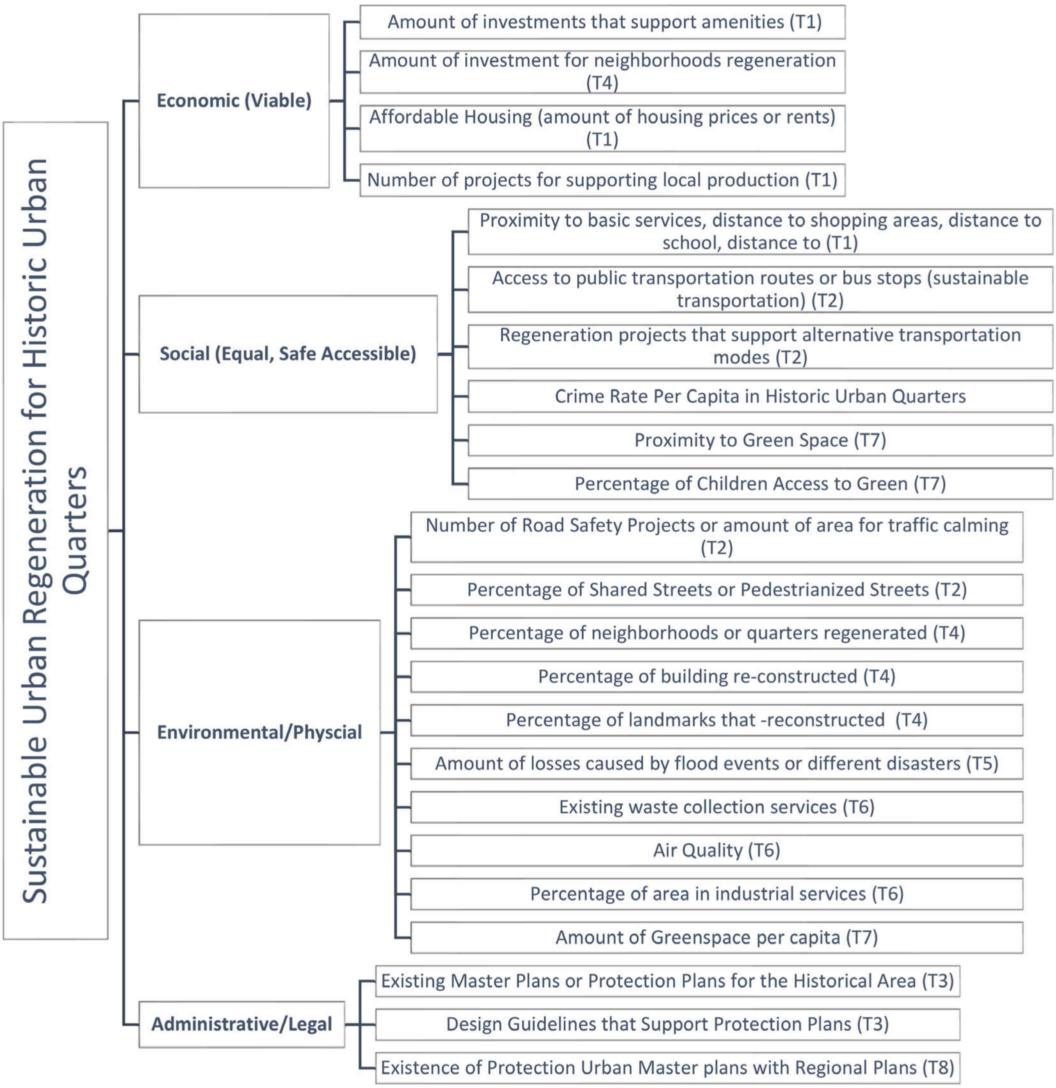


Figure 4. Hierarchy for Sustainable Urban Regeneration for Historic Urban Quarters.

Table 1. Comparison and weight results for the selected criteria set.

Main-Criteria	Weight	CR	Sub-Criteria	Weight	CR
(A) Economic	0.29	0.01	Amount of investments that support amenities (T1)	0.190	0.02
			Amount of investment for neighborhoods regeneration (T4)	0.185	
			Affordable Housing (amount of housing prices or rents) (T1)	0.273	
			Number of projects for supporting local production (T1)	0.352	
(B) Social	0.26		Proximity to basic services, distance to shopping areas, distance to school (T1).	0.162	0.02
			Access to public transportation routes or bus stops (sustainable transportation) (T2)	0.221	
			Regeneration projects that support alternative transportation modes (T2)	0.208	
			Crime Rate Per Capita in Historic Urban Quarters	0.131	
			Proximity to Green Space (T7)	0.118	
			Percentage of Children Access to Green (T7)	0.160	
(C) Environmental	0.30		Percentage of Road Safety Projects or amount of area for traffic calming (T2)	0.094	0.01
			Percentage of Shared Streets or Pedestrianized Streets (T2)	0.087	
			Percentage of neighborhoods or quarters regenerated (T4)	0.100	
			Percentage of building re-constructed (T4)	0.072	
			Percentage of landmarks that were reconstructed (T4)	0.060	
			Number of losses caused by flood events or different disasters (T5)	0.120	
			Existing waste collection services (T6)	0.163	
			Air Quality? (T6)	0.101	
			Amount of area in industrial services/total area(T6)	0.061	
			Amount of Greenspace per capita (T7)	0.140	
(D) Administrative Legal	0.15		Existing Master Plans or Protection Plans for the Historical Area (T3)	0.367	0
			Design Guidelines that Support Protection Plans (T3)	0.340	
			Existence of Protection Urban Master plans with Regional Plans (T8)	0.293	

3. Data Collection and Results

One of the most challenging aspects of the current study was the scope of data collection. Whereas in many regions public and transparent data on issues such as spending, occupation, taxes, subsidies, crime rates, and funded projects are available, in this case, similar to many other parts of the region, accessing detailed economic data is not feasible [59]. Even when available, the data are very general and lack necessary details suitable for AHP analysis. The current data sets addressing 24 sub-criteria for two alternatives were collected using police department reports, UNDP, municipalities, the antiquities department, the environment department, the town planning department, available GIS data, Open Street Map (OSM), existing literature, master plans, and housing market websites. It must be noted that AHP is especially helpful in these cases when the influencing factors are numerous, intricate, interrelated, from different sources, or even at odds with one another. [24,42,60]. This approach, coupled with the expert evaluation, ensures that the results address the intrinsic complexity of the topic from multiple perspectives.

3.1. Economic Dimension

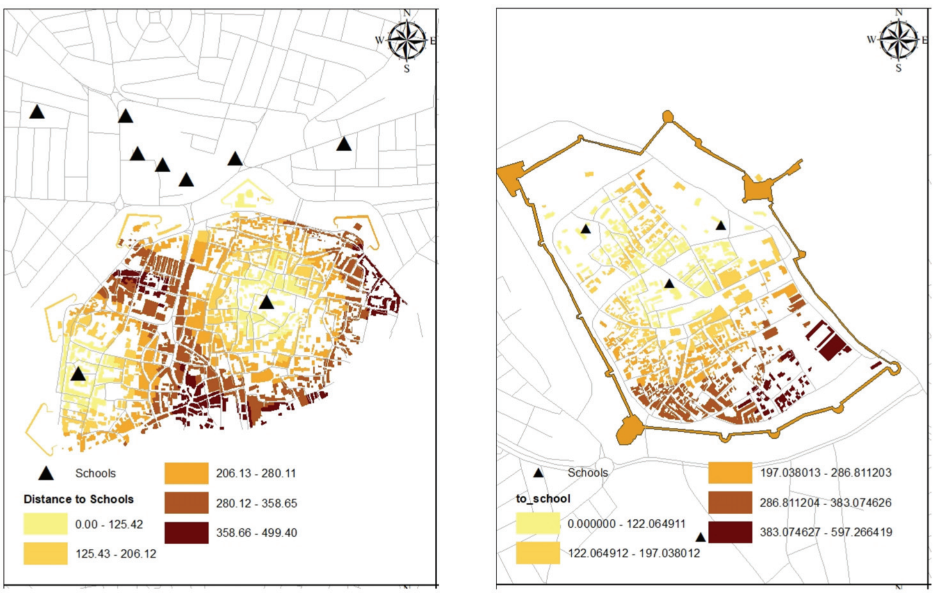
Amount of investments that support amenities (T1): The economic sub-criteria were evaluated using different data collection methods. The amenities were evaluated based on their frequency as displayed on the Open Street Map (OSM) platform. OSM has proven to be a reasonably reliable image of the region's public amenities [46]. The numbers were first adjusted for the area in each case before conducting a pairwise comparison. Northern Nicosia, due to its administrative dimension and centrality, contains more public amenities compared with Famagusta. Nevertheless, these amenities are not equally distributed across the area and are more focused on central parts and tourist attractions.

Amount of investment for neighborhood regeneration (T4): Neighborhood regeneration investments are more numerous in Northern Nicosia. Many neighborhood regeneration plans have been proposed and implemented over the last two decades within the framework of the Nicosia Master Plan, which is an ongoing effort to preserve Nicosia's urban and architectural heritage regardless of its borders [49,51]. These projects in northern Nicosia included housing rehabilitation programs in Arabahmet, Samanbahce, and Selimiye [61]. Famagusta, on the other hand, has seen very limited investment for neighborhood regeneration, and the majority of the focus has been oriented toward more significant historical buildings and monuments [62]. Although small social housing units have been constructed on the northern side of the walled city by the municipality, the area lacks a clear plan for investing in neighborhood regeneration.

Affordable Housing (amount of housing prices or rents) (T1) and Number of projects for supporting local production (T1): Housing affordability was measured by exploring all available sales and rental options on the two major websites that are widely used in the region (23 cases in Nicosia and 14 cases in Famagusta). The collected prices were adjusted by area, and the averages were used for the comparison. The average price of housing is relatively higher in Famagusta (GBP 1029 per m2) compared to Nicosia (GBP 788 per m2), but the range of prices is much wider in Northern Nicosia (GBP 2228-246 per m2) compared to Famagusta (GBP 1400-418 per m2). What is more, the physical condition of housing in Northern Nicosia varies from neighborhood to neighborhood. For the criterion addressing local production, the number of workshops, shops, and non-governmental organizations supporting local production were counted and compared (adjusted for population). Nicosia, due to its centrality, higher tourist numbers, and its closeness to the border, has more activities associated with local production. Supporting local production and local involvement, which is an intrinsic dimension of Target 1, is a critical aspect of resilient neighborhood regeneration. Putting emphasis on mere physical improvement can create undesirable social side effects such as gentrification and unintentional displacement of the local population. Therefore, exploring the success of a regeneration plan needs to include intentions for the future stability of the social fabric.

3.2. Social Dimensions

As with the economic dimension, each social sub-criteria value was obtained from different resources. Accessibility to basic services and green spaces was analyzed in a GIS environment by using the near distance tool. Within the historical environments, the distances from schools, markets, and green spaces were calculated (see Figure 5) and the average distance from each house was added to evaluation Table 3. According to the local municipalities, regeneration projects that support alternative transportation modes are very limited. There are only a few pedestrianized roads in the historical environment. The percentage of crime values was generated with population data, and total crime values were obtained from local police and planning. In addition, the case area's proximity to green space and the percentage of children's access to green spaces were investigated.

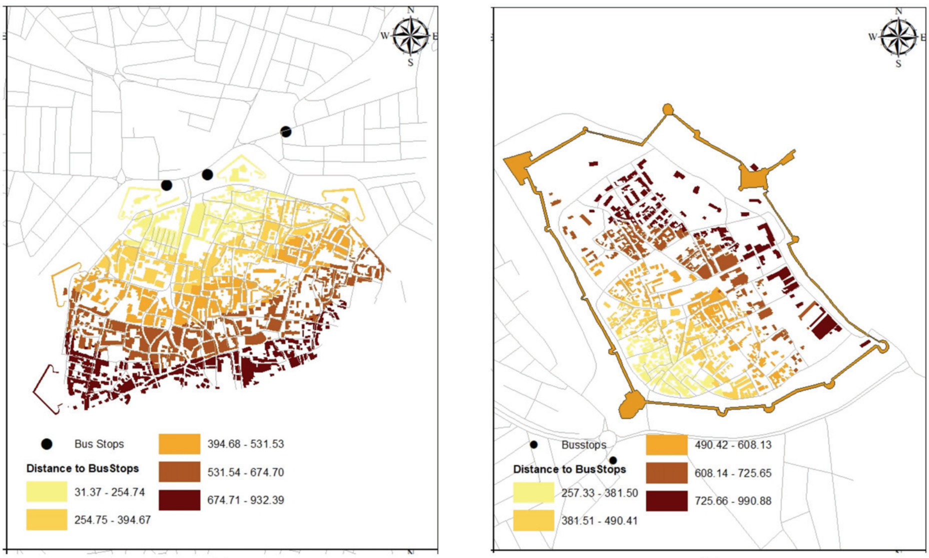


(a) (b)

Figure 5. Accessibility to Schools in Nicosia (**a**) and Famagusta (**b**) Walled Cities.

Proximity to basic services, distance to shopping areas, and distance to school (T1): Accessibility to basic services is one of the essential dimensions of sustainable urban development. This is particularly critical regarding local accessibility because it would reduce the necessity for vehicular traffic [63]. Local accessibility improvement would allow people to conduct many activities of their daily lives within their neighborhoods [64] and has a direct impact on their quality of life [65]. The sub-criteria, in this case, were measured by averaging the distance from all residential units to the local government schools. Both cases contain schools within the walls, and the network structure is relatively similar in both cases (Figure 5). Therefore, both cases, although isolated from the city to some extent, show high internal accessibility, which is expected from organically developed historic urban tissues (see [66]).

Access to public transportation routes or bus stops (sustainable transportation) (T2): Public transportation plays a key role in developing cities that are less car-dependent and more sustainable [67]. Having a bus stop within walking distance has a significant impact on residents' mode of transportation, which reduces traffic and pollution while encouraging walking [68]. Equal access to public transportation for all residents is a social necessity for sustainable development [69]. In this case, the two cities are highly dependent on cars, and public transportation remains limited to the services provided by the universities [70]. The buses do not enter the walled city and are not permitted to do so due to their weight and size. Furthermore, there is no support for smaller shuttle buses that can supplement the existing system. Accordingly, all bus stops and routes are directly connected to the gates and are not highly accessible (Figure 6), especially considering the peak climate conditions, which might make walking to the bus stops undesirable.



(**a**) (**b**)

Figure 6. Accessibility to Bus Stops in Nicosia (**a**) and Famagusta (**b**) Walled Cities.

Regeneration projects that support alternative transportation modes (T2): There is very limited access to alternative transportation modes in both cases. There are some private bicycle stands supported by local mobile phone companies, but these facilities are often oriented toward touristic activities and not usable by the local residents. What is more, there are no dedicated bicycle lines that encourage locals to use alternative modes of transportation. Sustainable transportation in this regard is highly influenced by the way people imagine and think about it in terms of their daily routines [71]. Therefore, it could be assumed that the degree of availability of infrastructure supporting alternative transportation modes would impact people's attitudes toward them. Alternative transportation models in this sense can be considered a socio-cultural phenomenon where even the norms of what constitutes normal—or even acceptable—transportation vary from context to context [72]. Moreover, a combination of alternative and public transportation would have a much stronger positive environmental impact [73].

Number of Crime/Crime Rate Per Capita in Historic Urban Quarters (2011–2020): The region is known to have a very low crime rate, especially regarding violent crimes [74]. This is evident from the nine years of data that are presented here. The crime rate data were collected from the police departments of both cities. In this case, instances of crime have been recorded with street names but do not provide exact coordinates (Table 2). The majority of these crimes are shoplifting and petty theft, which shows the concentration of these activities around commercial areas. However, even a trivial crime rate indicates the presence of inequality, social stratification, poverty, and crime rate as interconnected topics [75]. The relationship between crime and neighborhood regeneration is complex [76] and goes beyond the scope of this study. In general, reducing crime rates is essential to achieving sustainable neighborhood regeneration; nonetheless, neighborhood regeneration can decrease the crime rate by creating new opportunities [77,78]. In both cases, it is evident that the crime rate is higher in areas that have undergone some renovation and are tourist destinations, which makes them more vital and vibrant with microeconomic activities and consequently more prevalent for the aforementioned type of crime that occurs in the city.

Table 2. Crime Analysis in Nicosia and Famagusta Walled Cities.

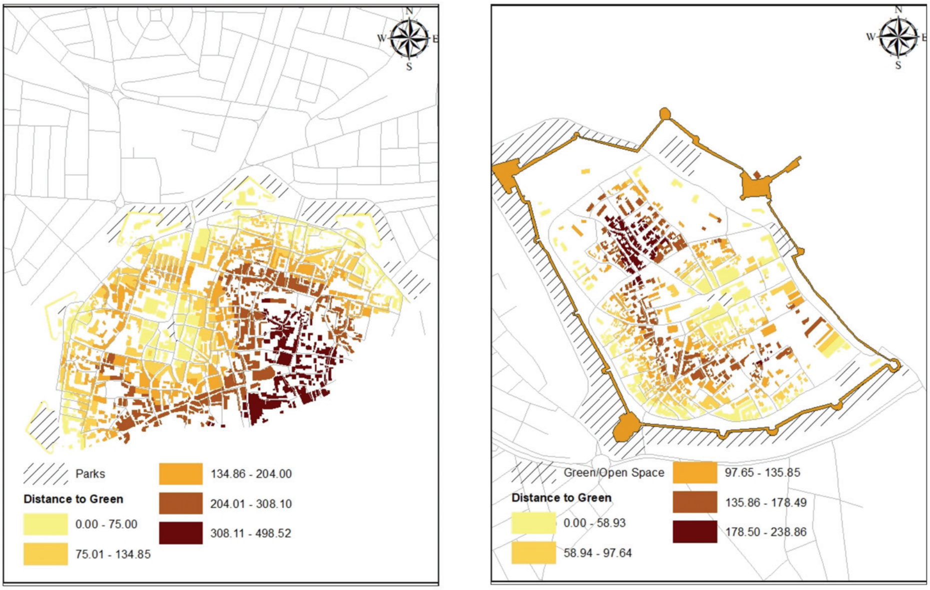
	Nicosia			Famagusta		
Years	**Population**	**Amount**	**Ratio**	**Population**	**Amount**	**Ratio**
2011	6800	298	0.04	1476	3	0.00
2012	6815	343	0.05	1472	2	0.00
2013	6835	321	0.05	1462	9	0.01
2014	6888	274	0.04	1459	32	0.02
2015	6956	211	0.03	1459	33	0.02
2016	6950	216	0.03	1443	59	0.04
2017	6958	204	0.03	1430	35	0.02
2018	7087	236	0.03	1442	58	0.04
2019	7181	262	0.04	1447	22	0.02
2020	7152	215	0.03	1427	31	0.02
		OVERALL	0.04			0.02

Proximity to Green Space (T7) and Percentage of Children's Access to Green (T7): Providing just and proper distribution of green spaces throughout the city is a critical dimension of regeneration planning [79]. Both cases are dense organic urban tissues with walls and moats; accordingly, the largest green space for both cases is the moat. This historic defensive element now serves as a green pedestrianized path in both cases, albeit access to this space is limited through the gates of the walled cities. The central public spaces of both cities present open public spaces with some greenery, although this is more prominent in the case of Famagusta. Children's access to green spaces was determined by proximity to parks with designated areas for playgrounds—albeit at a smaller proxy. Famagusta has a slight edge over Nicosia regarding this criterion; with a children's playground located at the heart of the city, it provides better and more accessible green areas for children (see Figure 7).

3.3. Environmental/Physical Dimensions

The targets regarding the physical and environmental aspects of cities are very versatile within the framework of SDG-11. In this case, ten criteria were used to evaluate the two alternatives (addressing targets 2, 4, 5, 6, and 7). Screening UNDP project documentation, publicly shared information made available by municipalities, the LIPA 2019 socio-economic survey for the Gazimağusa Iskele and Yeniboğaziçi Master Plan, the Environment Department, and the Town Planning Department were used to collect the data. Some criteria were evaluated using analysis conducted on GIS maps of the region.

Number of Road Safety Projects or amount of area for traffic calming (T2): Road safety projects can significantly reduce the number of accidents [80], and they play a significant role in the success of urban regeneration projects [81]. In this case, the instances of road safety measures and their locations were collected from musicality maps. Both cities utilize measures such as speed control cameras, raised curbs, speed bumps, road textures, mirrors for sharp turns, and active police patrols. The entrance to both walled cities is limited by the weight and size of the vehicle. Although both cities have reasonable road safety features, Nicosia performs better. This is most likely due to its centrality, resources, and budget.



(**a**) (**b**)

Figure 7. Accessibility to Green Space in Nicosia (**a**) and Famagusta (**b**) Walled Cities.

Percentage of Shared Streets or Pedestrianized Streets (T2): The impact of pedestrian movement on the quality of life in cities is well documented in the literature (see [82]). The comparison was conducted using data collected from the municipalities of the two cities. Nicosia has seen much more development in terms of road safety projects and pedestrianization efforts in line with its comprehensive master plan. Both cities include pedestrianized segments mainly around historic landmarks, but the efforts are more spread out and regulated in Nicosia. In this case, the comparison was conducted via the volume of pedestrianized space relative to the size of the walled cities.

Percentage of neighborhoods or quarters regenerated (T4): As mentioned before, only Nicosia hosts officially regenerated neighborhoods, namely, the housing rehabilitation programs in Arabahmet, Samanbahce, and Selimiye [61]. In Famagusta, neighborhood regeneration efforts are mainly limited to personal investments. The criteria weights here were generated by comparing the relative areas of residential neighborhoods that have gone through some regeneration.

Percentage of buildings (listed) reconstructed (T4), and Percentage of landmarks that reconstructed (T4): Within the framework of target 4 of SDG-11, the protection, rehabilitation, regeneration, and reconstruction of historic buildings and landmarks are highlighted [83]. The capital investments required for these protection plans need to be secured via multiple levels of government, including local communities, local administrations, the private sector, national governments, and global institutions—especially as outlined in indicator 11.4.1 [84]. Accordingly, the extent of these efforts illustrates the level of attention that exists surrounding a historic site from different perspectives. In this case, information was gathered through UNDP, municipalities, and the Antiquities Department. In terms of landmarks and more significant urban heritage, both cities have a good track record due to findings secured via UNDP programs. Nevertheless, urban tissues, residential buildings, and less-significant built heritage are less visible in these plans. These buildings require more engagement from private and local stakeholders. Examples of private investments in this regard can be seen in the rehabilitation of many residential buildings into cafes, shops, and tourist gift shops. It is necessary to note that, in accordance with all regeneration charters, preservation of the context is as critical as the landmarks. This requires more attention in both cases.

Number of losses caused by flood events or different disasters (T5): Target 5 addresses issues related to the prevention of loss of life, particularly those associated with preventable causes. In this case, there are no recorded losses of life in the contemporary histories of the two cities caused by natural disasters, famine, or economic despair. The only real neural phenomenon that causes some problems is flooding, which is not severe and has not caused any loss of life.

Existing waste collection services (T6): A robust waste management system is vital for sustainable and resilient urban regeneration efforts [85]. Data were collected from the municipalities, and from a survey that was conducted by LIPA in 2019 addressing the occupancy evaluation of waste management systems. Waste management was ranked as the most important environmental sub-criterion by the experts (see Table 1). Although there are efforts for systematic separation of waste by material and recycling, these efforts are still very limited, and most collected waste finds its way into landfills [28]. Nevertheless, both cities are kept relatively clean. The sewage system, however, is lacking, and the majority of houses use septic tanks. Due to the historic layering of the city, the realization of an underground sewage system seems to be harmful.

Air Quality (T6) and Ratio of areas in industrial services (T6): These factors correspond to Target 6. Both cities have very low air pollution, and they are very similar in this regard; however, Famagusta's proximity to the cargo port might be a cause for concern for air pollution. In both cases, the industrial functions are located outside the walls, and very small areas are occupied by industrial land use (some car repair shops).

3.4. Administrative Dimensions

The administrative criterion was assessed using three sub-criteria, which primarily addressed Targets 3 and 8 of SDG-11: existing master plans or protection plans for the historical area (T3), design guidelines that support protection plans or policies (T3), and the existence of protection urban master plans with regional plans (T8). Accordingly, if a corresponding official document for each criterion was extant in both cases, it was marked as equal; otherwise, the city where those conditions were met was evaluated higher. Nicosia has a comprehensive master plan compared to Famagusta, which does not have an officially published master plan. It must be noted that Famagusta, a walled city, has a revitalization plan, but it is not officially published and is referred to more as a general guideline. The revitalization plan for Famagusta has a set of design policies and protection targets for regeneration and upgrading the historic cultural environment. The National Physical Plan (2015) also has goals and targets for Famagusta, but it does not have any economic, social, or physical items for the historic walled city.

Criteria values and resources which data were collected is shown in Table 3.

After obtaining the criteria values for the case areas, AHP-generated weights and criteria values were combined using the Simple Additive Weighting (SAW) formula (see Equation (1)). SAW is a multi-attribute procedure based on the concept of a weighted summation:

$$f(x) = \sum_{j=1}^{n} \left(W_j \cdot X_{nij}\right) \tag{1}$$

where W_j is the relative importance weight of criteria j, X_{ij} is the standardizing value of area i under criterion j, and n is the number of criteria. Each criterion was summed for the calculation of the main criteria values by using the formula. As can be seen from Figure 8, Nicosia's walled city (North) is more sustainable than Famagusta in economic and administrative terms. Physically and socially, they are very close (see Figure 8).

Table 3. Evaluation of the Criteria and Sub-Criteria for the case areas.

	Criteria/Case Area	Nicosia Walled City (North)	Famagusta Walled City	Resources
Economic	Amount of investments that support amenities (T1)	0.131	0.059	Authors: Open Street Map
	Amount of investment for neighborhoods regeneration (T4)	0.69	0.31	UNDP, Municipalities Antiquities Dept.
	Affordable Housing (amount of housing prices or rents) (T1)	0.155	0.118	Authors: local real estate services
	Number of projects for supporting local production (T1)	0.211	0.141	Authors: Open Street Maps
Social	Proximity to basic services, distance to shopping areas, distance to school, distance to (T1)	0.757	0.787	Authors: GIS
	Access to public transportation routes or bus stops (sustainable transportation) (T2)	0.527	0.45	Authors: GIS
	Regeneration projects that support alternative transportation modes (T2)	0	0	UNDP, Municipalities Antiquities Dept.
	Number of Crime/Crime Rate Per Capita in Historic Urban Quarters (2011-2020)	0.04	0.02	Police Dept.
	Proximity to Green Space (T7)	0.767	0.889	Authors: GIS
	Percentage of Children Access to Green (T7)	0.767	0.889	Authors: GIS
Environmental/Physical	Number of Road Safety Projects or amount of area for traffic calming (T2)	0.50	0.25	UNDP, Municipalities Antiquities Dept.
	Percentage of Shared Streets or Pedestrianized Streets (T2)	0.13	0.07	UNDP, Municipalities
	Percentage of neighborhoods or quarters regenerated (T4)	0.21	0.03	UNDP, Municipalities Antiquities Dept.
	Percentage of building(listed) reconstructed (T4)	-	-	UNDP, Municipalities Antiquities Dept.
	Percentage of landmarks that were reconstructed (T4)	0.28	0.25	UNDP, Municipalities Antiquities Dept.
	Number of losses caused by flood events or different disasters (T5)	0	0	Municipalities
	Existing waste collection services (T6)	0.75	0.77	Municipalities, LIPA (2019)
	Air Quality? (T6)	-	-	Environment Dept.
	Ratio of industrial services to total area(T6)	0.03	0.01	Town Planning
	Amount of Greenspace per capita (T7)	0.18	0.90	Authors: GIS
Administrative	Existing Master Plans or Protection Plans for the Historical Area (T3)	1	0	Town Planning
	Design Guidelines that Support Protection Plans or Policies (T3)	1	1	Town Planning
	Existence of Protection Urban Master plans with Regional Plans (T8)	1	0	Town Planning

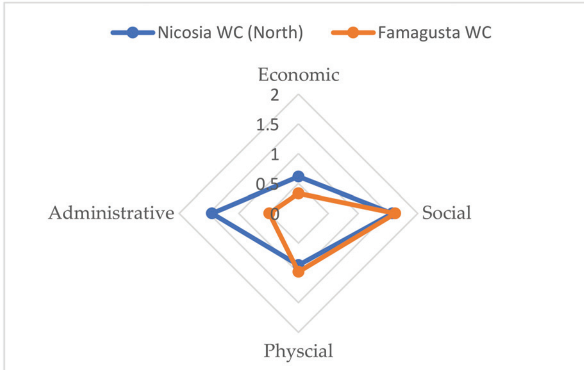


Figure 8. Comparison of Main Criteria Results for the case areas.

4. Discussion and Conclusion

In this study, urban renovation in historical and cultural heritage areas was evaluated within the scope of the sustainable urban development goal and targets. First, the SDG-11 target and sub-targets were examined, and a list of criteria for these objectives was created corresponding to the relative circumstances of the two case studies. The weights of these criteria have been demonstrated by experts using the AHP method. After the determination of relative weights, all criteria were analyzed, and the values found were normalized in the range of 0–1. After this stage, all data related to the Nicosia Walled City and Famagusta Walled City regions were collected, and the basic criteria and sub-criteria for sustainability were compared with criteria weights.

The United Nations' sustainable development goals, even when explored individually, are highly complex and interconnected concepts. Contextual preferences add an extra layer of complexity to projects aiming for tangible progress toward the SDGs. This is more apparent in urban regeneration plans, which are highly contextual and correspond to different layers of local populations and stakeholders [86]. Complexity is an intrinsic quality of cities [87], which makes approaching Goal 11—sustainable cities and communities—that includes a multitude of criteria more challenging. What is more, the data associated with different dimensions of an urban regeneration project can come from a multitude of sources. Superimposing these data layers requires methodological innovations and interdisciplinary explorations. Thus, decision-making encapsulates these challenges, requiring a method that can address different criteria at once. AHP was used in this study to highlight a methodological possibility for addressing these complexities with regard to multiple data sources while hearing the voices of local experts. What is more, the involvement of stakeholders in regeneration plans is essential to moving toward the SDGs [20], and AHP can provide a framework for different voices to be heard. Future studies can further explore the comparison of criteria weights generated by the different parties involved. This is critical as the image of neighborhood regeneration can differ from the viewpoint of local communities and governing bodies [88]. The current method aims not to remain merely top-down or bottom-up; rather, it aims to utilize both. What is more, the diversity of supporting data sources makes the approach more comprehensive. In this case, the outcome did not merely reflect the point of view of experts, the department of antiquities, or the municipalities, for instance, but rather a combination of them.

The experts, in this case, evaluated economic, social, and environmental criteria as almost equally important, followed by the administrative criterion. The weighting of sub-criteria was a much more complicated process consisting of a multitude of data layers from different sources in two cases. The results show that each city has unique strengths and shortcomings in its regeneration approach when aiming for SDG-11. Northern Nicosia scores higher in most sub-criteria because it has a clear master plan, some neighborhood regeneration projects, better road safety, affordable housing, and pedestrianization schemes. This might be attributed to the centrality of the city, its population, and the flow of capital through it, which makes many of these projects feasible in the eyes of stakeholders. Famagusta, on the other hand, only excels in terms of the amount of green or open space per capita. In general, walkability and accessibility seem to be highly influential dimensions of sustainable regeneration efforts.

The importance of proper planning for land use in a growing, conflicted city is a concern. In both cases, the Cyprus conflict has left its mark, slowing regeneration efforts and especially international investments. Making a meaningful connection with the tourism sector by highlighting local culture and contextual values in the regeneration plan would make Nicosia's regeneration plans more resilient [89]. Within the context of Nicosia, Atun [48] argues that regeneration plans should be a link between the past and future of the city. As one of the rare communal efforts between the north and south sides, these urban master plans could serve to create a more sustainable future for the cities. Savvides [90] shows the critical importance of accounting for residential and housing rehabilitation within the framework of the regeneration of Nicosia. In a regeneration plan, the housing sector is the seed for improving the economy and local job market. Although the administrative criterion was evaluated lower than the main pillars of suitability, it encapsulates and guides those criteria if conducted properly. It could be argued that the reason why Northern Nicosia scores higher across sub-criteria concerning SDG-11 is its masterplan, which is lacking in the case of Famagusta.

One of the current study's findings was the apparent lack of attention paid to urban residential tissue when compared to well-known historic buildings. Affordable and socially inclusive housing is an essential component of sustainable urban regeneration planning and policies [91]. Thus, regeneration efforts targeting long-term sustainability need to pay closer attention to the residential tissue that is associated with the everyday life of the city. This is particularly important as both sites are points of interest for UNDP, so it could be argued that a more comprehensive approach that does not solely focus on the physical restoration of structures needs to be implemented. Furthermore, it cannot be denied that economic issues are the most central in terms of immediate impact on sustainable urban regeneration plans [92]; therefore, the micro-economy that empowers local production, involvement, and investigation is critical. This is critical as lack of attention to the local population can lead to displacement (intentional, incremental, or as a side effect of the economic transformation), transformation of the social fabric, and gentrification in some cases; these are well-known phenomena that occur when the planning parties are disconnected from the setting [88,93]. Therefore, the involvement of the local communities in the decision-making process is critical in achieving more sustainable and resilient future neighborhoods that aim for regeneration without displacement [93]. In this regard, AHP provides a methodological possibility for the involvement of different parties together with various secondary data sources.

In the end, it must be noted that this study was not without limitations. Many dimensions such as cultural heritage, social neighborhood structures, place attachment, and identity are influential elements of planning for urban regeneration [94], which are not investigated in this paper. Nevertheless, the methodological novelty of the study indicates the possibility of creating more inclusive and complex AHP models. Accordingly, future studies are required to expand on the list of criteria and to include other SDGs in the model.

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Testing Olmsted's Lasting Legacy—Comparing Design Theory and the Post-Occupancy Conditions of New York Central Park

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Abstract: Social media is a rapidly developing field in architecture and landscape research, which is used to understand public opinions and landscape use. The year 2022 sees the 200th birthday of Olmsted, the founding father of landscape architecture in America. While we commemorate Olmsted's ground-breaking contribution to the landscape architecture discipline, in-depth analyses are always required to examine historic legacies for their current relevancy. Taking his first practical work, New York Central Park, as an example, this paper systematically revisits Olmsted's park design theory and vision, and investigates its post-occupancy conditions from 11,501 posts on TripAdvisor. The results show that the current park use pattern confirms the validity of his scenic image theory. At the same time, his design works have become increasingly popular as public projects to foster social interaction.

Keywords: Olmsted; New York Central Park; social media data; text analysis; landscape heritage; applicability

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1. Introduction

Olmsted is a fundamental figure in landscape architecture history. He founded the discipline of landscape architecture in America and completed nearly 500 projects during his lifetime [1]. The great works he left in hundreds of American cities were not only designed as environments for daily use, but also represent a collection of living design literacies and principles. 2022, the bicentennial of Olmsted's birth, is an appropriate time to contemplate Olmsted's legacy. In the parks that have served the public for more than 100 years, what design programs have survived and thrived? What design literacies and principles are still relevant to daily use? What new elements emerge that enhance experiences of the public space? Until we find answers to these questions, it is difficult to argue that our commemoration of Olmsted pertains to the design practice of still-relevant public spaces.

This study used New York Central Park as a case study. As Olmsted's famous and most representative work, this park was the first of its kind in the United States that truly served the public, and it remained of great significance to both Olmsted's legacy and the society for which it was designed, as well as contemporary society [2]. In designing Central Park, Olmsted created landscape design as an occupation, and chose it as his career [3]. Central Park marked the birth of public landscapes and the birth of the discipline of landscape architecture [2]. This does not mean that the park never faced challenges. In the 1830s, due to the influx of immigrants into New York, the grid layout of the city was destroyed, and Central Park provided entertainment places and healthy leisure areas for every citizen of all classes in the city [4]. When it was first built, Central Park was very popular, and the number of daily visitors reached 2% of the population of New

York City [5]. However, its brilliance dimmed at the beginning of the 20th century. The maturation of public transportation made long-distance travel popular, which allowed people to experience real nature far from the city [4]. Park visitation fell sharply, and the park managers' ignorance led to its first decline [4]. In 1934, a large number of leisure and entertainment facilities were built, including 19 playgrounds, ballfields, handball courts, and Wollman Rink, to return it livelihood [6]. In the 1960s and 1970s, rapid suburbanization, and a lack of funds and personnel, led to the second decline. The park management committee, established in 1980 [4], effectively restored the park landscape and held large-scale activities such as concerts, festival celebrations and protests [6]. Today, Central Park still responds directly to the expectations of the population and public life in New York [4]. The Park Conservation Association spends nearly USD 78 million a year on the care and maintenance of the park [7] (Central Park Conservancy, https://www.centralparknyc.org/about accessed on 20 June 2022). Today, New York Central Park is loved by Americans and people throughout the world. Currently, more than 42 million tourists visit every year [8] (Kang, 2017, https://www.centralparknyc.org/articles/central-park-history accessed on 20 June 2022). By examining the historical maps (Figure 1), the changes to the park's program can be understood with greater clarity. However, the impacts of different programs in the park still remain little understood by most designers.

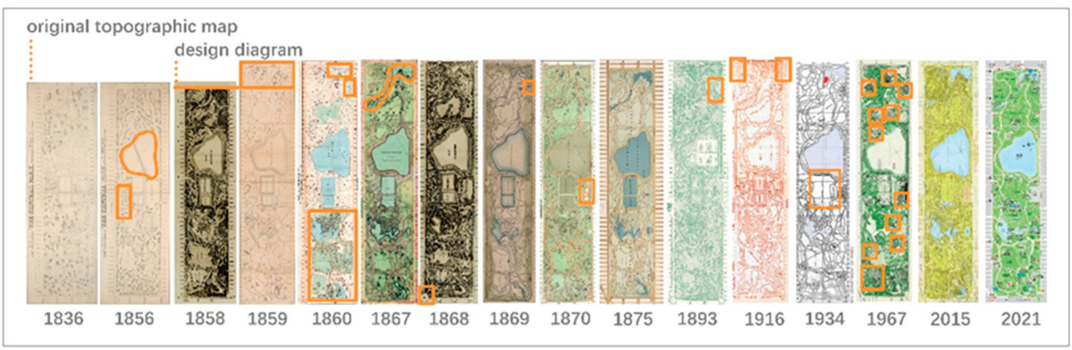

Figure 1. Pictures of plan changes in Central Park from 1836 to 2021 (Source: The maps of the park are from the Library of Congress website and were compiled by the authors.).

The overarching aim of the study was to explore the validity of Olmsted's design theory in the contemporary context. This raised the following research questions:

1. How did Olmsted envision the landscape elements, activities, and tourists' perceptions in the park?
2. What landscape elements will the current users prefer, what activities are they more willing to participate in, and what perceptions will they have of the landscape site?
3. What is the relationship between the landscape elements focused on by the tourists, the activities there in and the perceptions of the site?
4. What lessons can we learn by comparing Olmsted's original theory and the current usage pattern of Central Park?

2. Methodology

2.1. Research Framework

Two sets of data were used for this study. First, Olmsted's original design theory was extracted from the surviving literature and archives. Second, social media data about Central Park posted on the TripAdvisor platform in 2017 were used to reflect current users' observation, behaviors, and perceptions of the park. Both sets of data were sorted into the categories of landscape elements, activities and tourists' perceptions, which were compared. The study framework is shown in Figure 2.

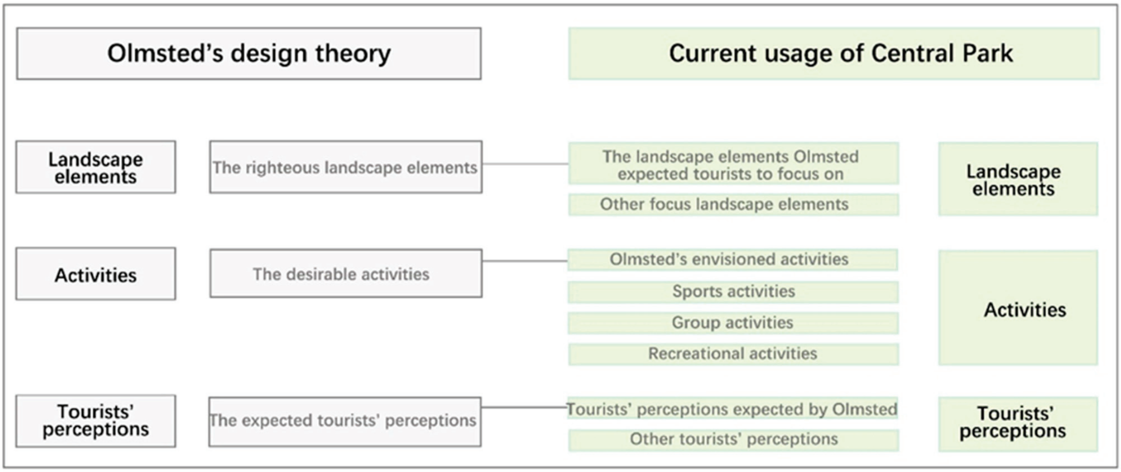

Figure 2. Study framework (Source: drawn by authors).

2.2. Olmsted's Design Theory Extraction from Literature

The data on Olmsted's design theory used in this study mainly come from the following sources:

1. The first source is *Frederick Law Olmsted: Essential Texts*, which was purchased by one of the authors on the AbeBooks website (http://abebooks.com/ accessed on 12 January 2021.). This book mainly collects 16 essays by Olmsted from the 1950s to the 1990s, revealing his thoughts on cities, residential sites, and the history and theory of urban parks. Most of Olmsted's design theories cited in this study are derived from this book.
2. The second document source is the official website of New York Central Park (https://www.centralparknyc.org/ accessed on 20 June 2022), which contains the historical records of the park, the description of the current uses of the park and the introduction of maintenance and management. In addition, in order to facilitate the research and protection of Central Park by tourists, students, teachers, scholars and professionals, the Central Park Conservancy provides a guide to researching Central Park and the Central Park Conservancy (https://www.centralparknyc.org/central-park-research-guide accessed on 20 June 2022). The research guide lists a large number of research materials in detail, including books on general park history, biographies, memoirs and papers, guidebooks and descriptions, annual reports, Department of Parks files, management reports and other official documents, and news about Olmsted's design ideas and the planning, design and management of Central Park. This study thus acts as an important source of literature and information.
3. The online website of the Library of Congress (https://www.loc.gov/ accessed on 20 June 2022) and the Official Website of the New York City Department of Parks and Recreation (https://www.nycgovparks.org/news/reports/archive accessed on 20 June 2022) were used to search for resources. There are various electronic materials in the Library of Congress, such as newspapers, books, printed material, photos, prints, drawings, and manuscripts about Olmsted and Central Park. Olmsted's manuscripts, historical photos, newspapers and historical maps of Central Park were selected from this website. The Official Website of the New York City Department of Parks and Recreation contains historical reports, press releases, and minutes related to all parks and public places in New York, and was thus also an important source for our research.
4. Finally, the Web of Science (https://www.webofscience.com/wos/alldb/basic-search accessed on 20 June 2022) database and China's National Knowledge Infrastructure

(https://www.cnki.net/ accessed on 20 June 2022) were used to search for research papers by other researchers. “Olmsted” and “New York Central Park” were selected as keywords. The research results regarding these scholars, as well as the papers and resources related to our research that they referred to, were used as a source of information here.

2.3. Current Usage of the Park Extracted from TripAdvisor Comments

2.3.1. Post-Occupation Comments Extraction from TripAdvisor

TripAdvisor, a worldwide travel guidance website, has been ranked first among all Google travel review websites [9]. Therefore, TripAdvisor posts were the main textual data we used; 11,501 pieces of comment data were obtained in the period from 1 January 2017 to 31 December 2017. The study only selected content independently disclosed by users for an aggregate analysis, and excluded users’ personal information.

2.3.2. Comment Processing and High-Frequency Word Coding

First, a code book was developed inductively by the authors by reading the comments separately, resulting in three categories: tourists’ focus landscape elements, activities, and tourists’ perceptions. Generally speaking, the nouns related to park use were recognized as the tourists’ focus landscape elements, verbs as user activities, and adjectives as users’ perceptions. For example, in the comment “Happy to get into this park. At this time, I am lucky to walk around with a different views and trees. I too try to bike around the park which are nice workshops”, “views” and “trees” were recognized as the landscape elements focused on by tourists, “walk” and “bike” were activities in the park, and “happy” and “lucky” were the perceptions of the tourists.

Within the three main categories, the code book further developed eight sub-categories and 62 third-level categories (Figure 3).

1. Landscape elements. This category reflected the tourists’ attention towards the park elements and facilities. This category was further divided into the landscape elements designed or mentioned by Olmsted (terrain, sound, color, material, view, waterscape, path, tree, lawn, etc.) and other elements (flower, plaza, sculpture, architecture, seating, lighting, service facility, playground, animal, etc.).
2. Activities. This category described the types of visitor activities undertaken in the park. It was further divided into four subcategories, including the activities envisioned by Olmsted (carriage, horse riding, relaxing and enjoying, sightseeing, talking, walking, sitting, sleeping, skating, rowing, traveling, eating), sports activities (exercise, run, bike, swing, climb, ballgame), group activities (wedding, gather, concert and show, political activity, religious activity, sing and dance), and recreational activities (draw and read, movies and theatre, market, photo-taking, entertainment games, exhibition, zoo and aquarium, museum).
3. Tourists’ perceptions. This category was further divided into the categories described by Olmsted (natural, healing, picturesque, quiet, spacious) and other perceptions (fascinating, funny, reminiscent, love, glad, busy, crowded, dirty, disappointing, expensive).

2.4. Data Analysis

In this study, the Big Data Workshop program developed by the researchers’ team was used to analyze data. The website is www.benzhi-studio.com: 7501 accessed on 25 June 2021. This program has three functions: 1. Statistics of word frequency given out by month. 2. Statistics of word frequency given by working days and rest days. 3. Statistics of correlation between different words. During its actual operation, the relevant comment text and code book were imported into the program.

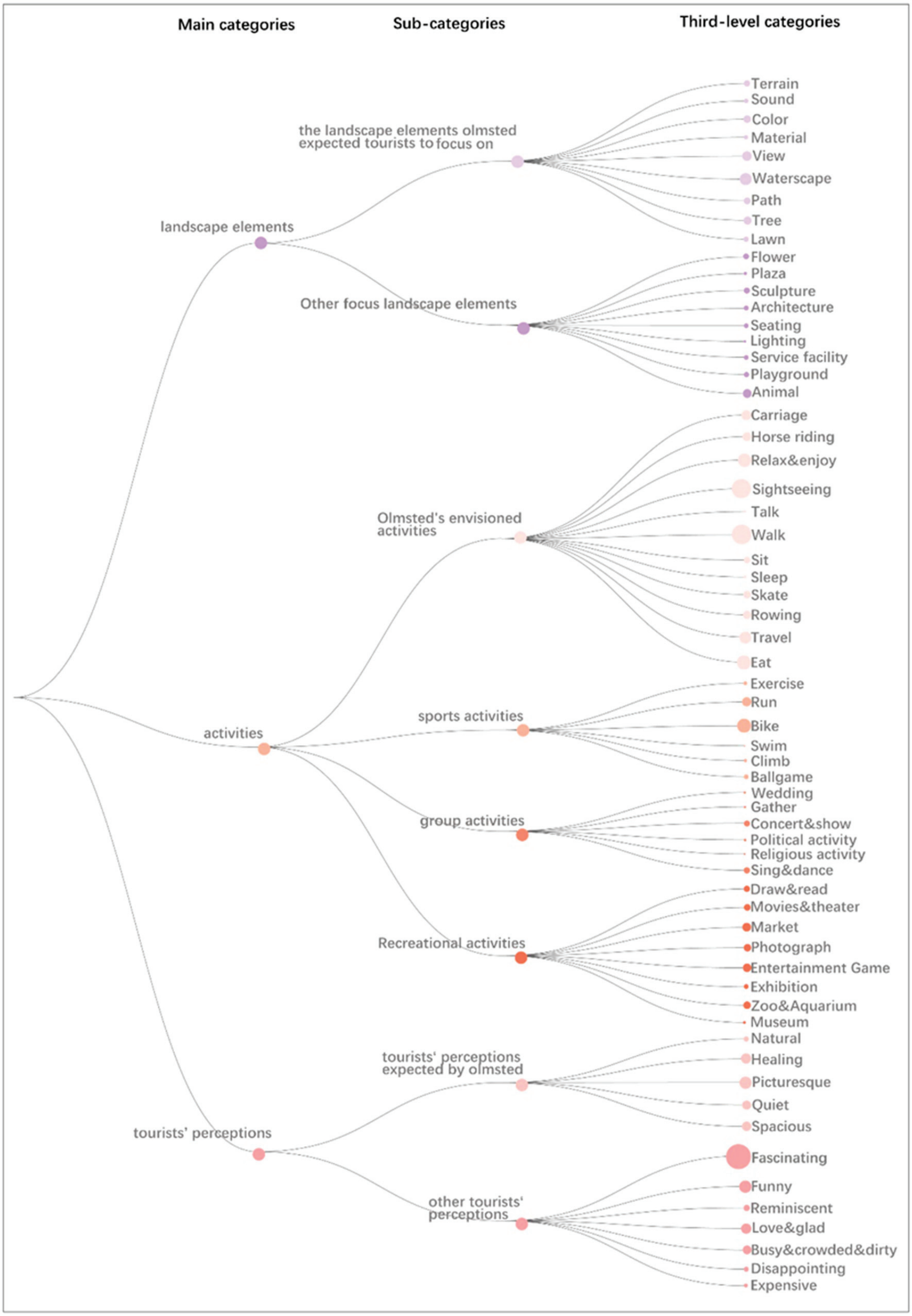

Figure 3. The code book (Source: drawn by the authors).

The Big Data Workshop program's ability to count word frequency by month was used to count the word frequency of each third-category word every month (discussed in Sections 4.1–4.3 of the article). The landscape elements that tourists focused on, activities they participated in, and their feelings and perceptions of Central Park in 2017, could be obtained. The final results of each word's frequency are shown in Table S1 of the attachment file. We have uploaded this to the submission link.

The third function of the program—to analyze the correlation between different categories of words—was employed in Sections 4.4–4.6 of the article. Words appearing in the same comment are here considered to have a correlation. For example, in the comment "I think that renting a bike looked like a fun way to see more of the park", "bike" and "fun" would be considered to have a correlation. Then, the exported data be processed. The correlation data between words in the same category were deleted, and only the data relevant to different categories of words were retained. Finally, the correlation data between landscape elements and activities, landscape elements and perceptions, and activities and perceptions be obtained. The specific data are shown in Tables S2–S4 of the attachment file.

Finally, we visualized the data. According to the chart, we can see more clearly the specific distribution of the three primary indicators, and their correlation mode and strength, which can reveal the qualitative causal relationship between park elements, activities and perceptions.

3. Olmsted's Design Theory

By reviewing Olmsted's original articles and archives, Olmsted's design theory was revisited under the topics of landscape elements, activities, and perceptions.

3.1. The Righteous Landscape Elements

Olmsted admired "picturesque" landscapes, so he worked on creating "natural-looking scenery". Landscape elements in a park should be arranged to take on a pristine appearance, in which visitors could feel "surrounded by the beauty of nature".

He believed the most essential elements of a park were the lawn, forests, and waterscapes—"The most essential element of park scenery was turf in broad, the two natural sceneries to be developed in public ground of great extent are forests and water" [10]—as these could create an idyllic atmosphere. In his mind, a lawn was necessary to creating picturesque park scenes [10]. The forest created a lush and mysterious effect that was more interesting and entertaining than an urban enclosure [10]. The waterscape could reflect the natural dynamics of wind and roll clouds [11]—"water will be best situated where it can be seen from the greatest number of widely distributed Points of view" [10]. Regarding the plant design in the park, the planting forms included solitary planting, group planting, and patch planting [10]. Plants could be used as the background or the main focus of the scenery. When used as the background, group planting and patch planting could be adopted, and the overall landscape formation was very important. When it was the main feature of the scene, solitary planting was favored to form a good individual viewing effect [10]. In terms of tree species selection, high branch points and large crowns were preferred, with more native species and less delicate, neatly trimmed plants. "Trees should be high-stemmed and umbrageous; conifers should be excluded, and flowers and delicate plants little if at all used except in vases and baskets or as fringes of architectural objects" [10]. The surface of the park should be smooth rather than rugged, and gently undulating rather than hilly. Plains, gentle slopes and grassland are the most suitable forms of terrain in the park [10].

Artificial elements were designed in organic forms or blended with natural elements. Olmsted thought that winding and rolling roads were more interesting, and straight roads were boring [10]. Therefore, the roads he designed were curved with smooth connections, creating various roadside sceneries [12]. He thought "the objection to monumental and architectural objects in works of landscape gardening is that they are not adapted to contribute to any concerted effect". He believed that elements such as architecture and sculptures should be kept to a minimum so as not to draw visitors' attention and detract from the overall effect [10], and they should be carefully integrated into the natural design to reduce any damage to the integrity of the scenic views [10]. The buildings should keep a low profile, and be consistent with the form of the landscape. The location, direction, elevation and contours of the buildings should be determined according to the characteristics of the surrounding sites. The locations of paved roads, the locations of trees blocking lines of sight and the locations of open lawns were all considered, as a gentle, quiet, dynamic, prominent and picturesque landscape is required [10]. Botanical gardens, zoos and other gardens should not be placed in parks. Their purposes are different from those of parks. They are two different kinds of entertainment. It would be better for them to be separate [10].

In short, Olmsted stressed the dominance of landscape scenery, while plants, waterscapes, roads, buildings, and other elements should form a coordinated landscape picture subservient to the overall theory [10]. The careful organization of simple elements should give visitors a profound sense of the landscape [10].

3.2. The Desirable Activities

Olmsted believed that peaceful recreation should be the main activity in an urban park, while noisy and exciting games and bad behavior should be prohibited. He believed it was necessary to make up for people's boring work through undemanding and quiet activities in the park. The enjoyment of scenery employs the mind without fatigue, and yet exercises it; it tranquilizes it and yet enlivens it. Through the influence of the mind over the body, this gives the effect of refreshing rest and a reinvigoration in the whole system [13]. Therefore, he advocated that the public should be guided through the park landscape to unconscious relaxation, rather than through noisy and exciting games or sports. Olmsted referred to this as "tranquilizing" recreation [13]. Olmsted believed that the park, as a complete landscape artwork, should maintain a pleasing state. If any activities undermined this work, it would reduce its attractiveness to tourists. Therefore, he formulated the rules and regulations of Central Park to ensure the park was used in the "proper way". Olmsted drafted the following rules, and had them posted in the park: "Not to walk upon the grass; Not to pick any flowers, leaves, twigs, fruits or nuts; Not to deface, scratch or mark the seats or other constructions; Not to throw stones or other missiles; Not to annoy the birds; Not to publicly use any provoking or indecent language; Not to offer any articles for sale" [14]. Over time, activities such as fishing, swimming, playing musical instruments, giving speeches and climbing walls were added to the activities he prohibited [2,14–16]. In addition, Olmsted had liked horse riding, rowing and skating since childhood, and he did not think that these activities were sports activities, but forms of transportation, so he designed enough space for these activities [17–19].

3.3. The Expected Tourists' Perceptions

Olmsted indicated that the greatest value of public pleasure grounds for large cities is in the rest they offer to the eyes and mind, and to the heart and soul, through their soothing charm, their fresh and inspiring influence, and the impersonal, non-overstimulating pleasure that only nature can offer to man [14]. As the closest place to nature in the city, urban parks should provide a place for spacious, quiet, natural, and picturesque experiences that restore calm [10]. He insisted scenery be use used to treat "excessive materialism" by alleviating "vital exhaustion", "nervous irritation", "constitutional depression", and the "loss of faith and lowness of spirit" [10]. Olmsted had a great sense of social responsibility, and took an active interest in the development of society and the public [20]. He believed that the overall health of society and cities depended on people's mental health, which could be guaranteed by rebuilding the connection between humans and nature [21]. Olmsted believed that urban parks served to create the same degree of "poetic beauty" as the original natural features present in urban areas [10]. They should present a feeling of "spaciousness and tranquillity" with a "variety and intimacy" of arrangement, thereby affording the most agreeable contrast to the "confinement, bustle, and monotonous" street-division of the city [5], and bring "the beauty of contemplation in the natural landscape" to the public. They provide a healthy form of recreation for city-dwellers and help park visitors to forget their mundane concerns [14]. As a natural landscape for the city, the park acts as a tranquil resting place for the soul, and brings people "tender, subdued and filial-like joy" [22]. Finally, the summary of all Olmsted's design ideas is shown in Table 1.

Table 1. Summary of Olmsted's design theory.

Category	Specific	Design Theory
Landscape elements	lawn	1. Lawn was necessary to creating picturesque park scenes
	forest	2. The forest created a lush and mysterious effect that was more interesting and entertaining than an urban enclosure.
	waterscape	3. Waterscape will be best situated where it can be seen from the greatest number of widely distributed Points of view.
	plants	4. The planting forms included solitary planting, group planting, and patch planting. High branch points and large crowns were preferred, with more native species and less delicate neatly trimmed plants.
	terrain	5. The surface of the park should be smooth rather than rugged, and gently undulating rather than hilly.
	road	6. Winding and rolling roads were more interesting, and straight roads were boring.
	architectures and sculptures	7. Elements such as architectures and sculptures should be kept to a minimum.
	buildings	8. The form of the buildings should keep a low profile and be consistent with the form of the landscape.
	Botanical gardens, zoos and other gardens	9. Botanical gardens, zoos and other gardens should not be placed in parks.
Activities	Activities he agreed to	1. Peaceful recreation should be the main activity in an urban park.
		2. The public should be guided through the park landscape to unconscious relaxation.
		3. Olmsted had liked horse riding, rowing and skating since childhood, and he did not think that these activities were sports activities, but forms of transportation, so he designed enough space for these activities.
	Activities prohibited by him	1. Noisy, exciting games, and bad behaviour should be prohibited.
		2. Not to walk upon the grass; Not to pick any flowers, leaves, twigs, fruits or nuts; Not to deface, scratch or mark the seats or other constructions; Not to throw stones or other missiles; Not to annoy the birds; Not to publicly use any provoking or indecent language; Not to offer any articles for sale.
		3. Fishing, swimming, playing musical instruments, giving speeches and climbing walls were added to the activities he prohibited.
Perceptions		1. Urban parks should provide a place for spacious, quiet, natural, and picturesque experiences that restore calm.
		2. Urban parks served to create the same degree of "poetic beauty" as the original natural features present in urban areas.
		3. Urban parks should present a feeling of "spaciousness and "tranquillity" with a "variety and intimacy" of arrangement.
		4. Urban parks act as a tranquil resting place for the soul, and brings people "tender, subdued and filial-like joy".

4. Big Data Analysis Results

The word frequencies of all third-level indicators were integrated into an analysis of the word frequencies of the three first-level indicators. The activities category was mentioned the most, 42,376 times (52.22%), followed by the perceptions category, 25,698 times (31.67%), and the landscape elements of focus category, with a word frequency of 13,069 (16.13%). These large numbers indicate the popularity of Central Park, showing that visitors' post-occupation comments about the park focused more on descriptions of activities and their own perceptions.

4.1. Analysis of Tourists' Focus on Landscape Elements

The landscape elements that tourists focused on in the park are shown in Figure 4. The waterscapes received the most attention, followed by the overall view of the park and the animals, trees and colors it contains.

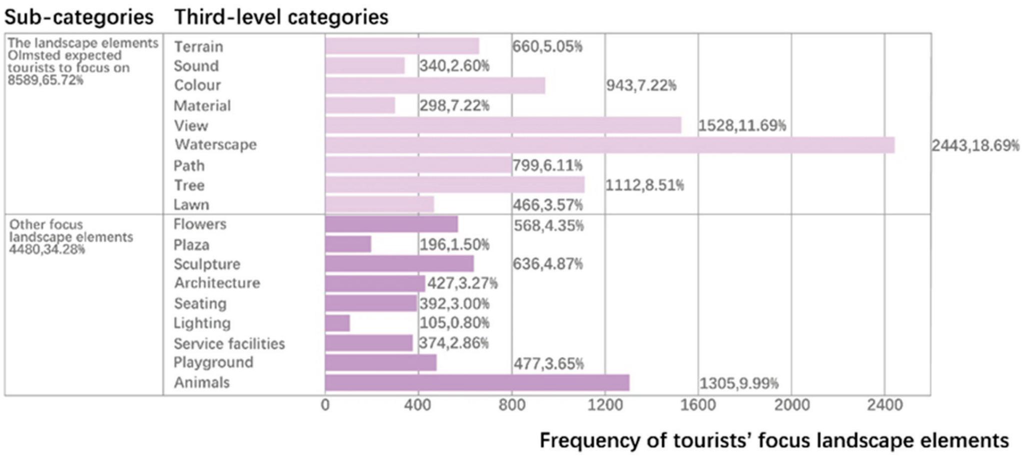

Figure 4. Distribution of tourists' focus on landscape elements (Source: created by authors).

Among the natural landscape elements expected by Olmsted to attract attention, waterscapes were the most popular with visitors, accounting for 18.69%, which confirms Olmsted's theory that "the waterscape should be designed in the most prominent position" [10]. The comments included not only descriptions of waterscape features, such as "The frozen lake is so scenic", but also of activities performed on the lake. The trees and lawns in the park also received some attention, accounting for 8.51% and 3.57%, respectively; as the current research results show, people usually preferred a natural environment with plants [23]. These comments not only included the praise of trees and the lawn—"The colours of the trees were amazing", "It was nice to see lawn and trees in a big city"—but also descriptions of related activities—"You can sing along with someone playing a guitar strummed Beatles song or lay out on the grass and have a special pic with your family". There were also some expressions of emotion—"When I actually go to the park and sat down to rest a little bit on the law. I gradually felt so calm and happy, just like in a movie". Sheep Meadow, the oldest green space in the park, was originally used as a pasture for raising sheep (as shown in Figure 5a). It was used to enhance the British pastoral quality of Central Park, and was only used as a place to enjoy the scenery, rather than for entertainment. After the sheep were moved out of Central Park in 1934, Sheep Meadow became a gathering place for public activities. The lawn is now not only part of the picturesque scenery of the park, but is also a place for people to undertake activities and socialize, as shown in Figure 5b. The terrain of the park was often mentioned by tourists in their comments, accounting for 5.05%. The gentle sloping terrain ingeniously designed by Olmsted is still considered beautiful in the minds of tourists—"Some great views from the castle. Random stair leading to the top of rock formations. Thick tree areas and open plains".

(a) (b)

Figure 5. (**a**) (**left**). Sheep in Central Park, c. 1900 (Source: Central Park Conservancy, 2021). (**b**) (**right**). Sheep Meadow, 2009 (Source: Central Park Conservancy, 2021).

The road cleverly designed by Olmsted also achieved the desired effect. In order to prevent the city from invading the park, he flooded all the transverse roads in the park to reduce and eliminate the presence of the urban landscape and sound [24,25]. Such an arrangement did not affect people's activities, nor hinder the traffic around the park. Tourists also paid attention to roads, with this constituting 8.51% of observations. Walking along the path, tourists could experience plenty of fun, away from the noise of the city—"It provides continuous enjoyment as you wander around the endless paths and avenues that criss-cross the park", "The screech of sirens was muffled as we leisurely wandered along the pathways".

Tourists also paid significant attention to the overall view in the park, with this accounting for 11.69%. The park landscape received praise for its scenic beauty, which was evident in comments such as "very clean park with unreal views!" and "we thoroughly enjoyed the beautiful view the park had to offer". Tourists also focused on the elements of color (7.22%), sound (2.60%) and materials (2.28%) in the park, which together formed the beautiful environment of the whole park—"Central Park is the greatest work of art in New York. Everywhere you go, at each turn, there is a wonderful vista which shows the eye of a landscaping genius".

People's attention towards flowers comprised 4.35% of observations, and their evaluations were very high. "There are flowers, making it romantic, fun and family friendly at the same time". Typhina's research also showed that parks with gardens are more popular [26]. However, Olmsted thought that parks should use less or no delicate flowers, because the colors of these flowers would disrupt the peaceful atmosphere in the park.

The sculptures (4.87%), playgrounds (3.65%), architecture (3.27%), plazas (1.50%) and other artificial elements in the park were also mentioned by many tourists, and comments indicated that these could enhance the attractiveness of the park—"The pounds, sculptures and bridges make this park stand out from others", "Belvedere Castle offers a territorial view of the park and the Merry Go Round is sweet". Just as in the current research, younger people have previously been found to prefer the artificial facilities in the park [27]. The park is more popular when containing more conveniences [28]. However, Olmsted believed that these elements were not in harmony with the natural landscape of the park and should feature as little as possible.

Central Park is an ideal place for bird watching and photography because of its diversity of animal species. Animals were the focus of 9.99% of the comment about Central Park. Birds, squirrels and other animals were described more frequently. Some comments praised them—"The squirrels running around was spectacularly"—and some described related activities, such as "You could hear birds singing and squirrels in the leaves", which increased the vitality of the park—"We had the added bonus of bumping into Big Bird too amongst the glorious changing colours of the trees and lovely peaceful landscape". In Olmsted's original design ideas, however, animals are not mentioned.

4.2. Analysis of Activities

The activities of tourists in the park are described in Figure 6. Among all activities, sightseeing and walking were the most popular, followed by eating, cycling, and relaxing in the park.

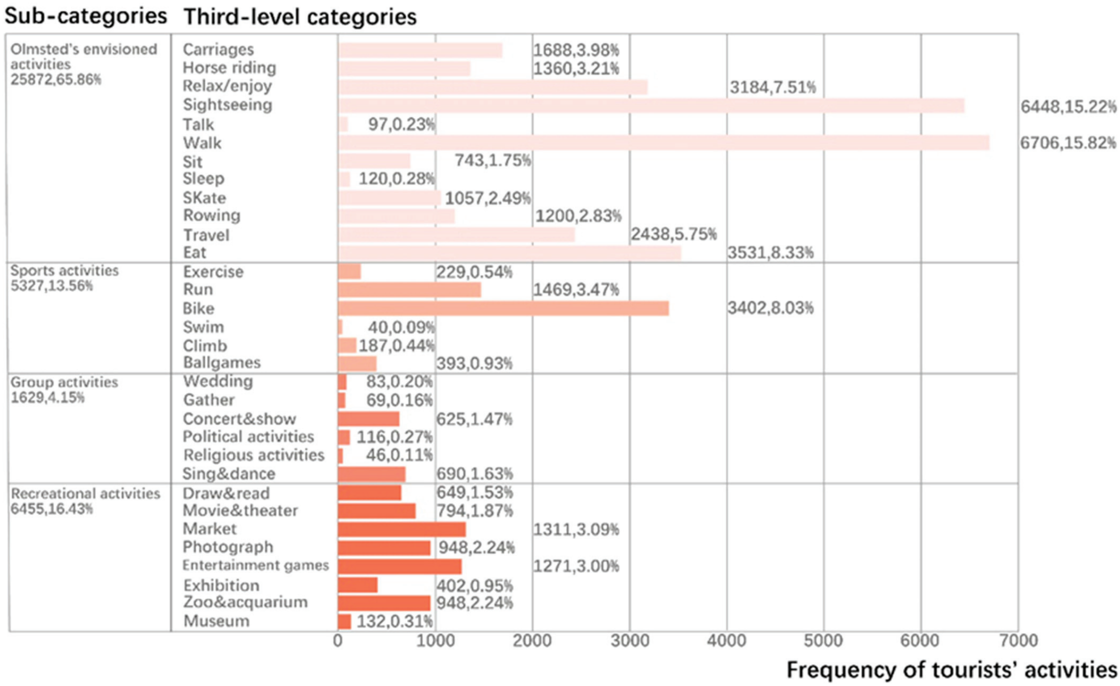

Figure 6. Distribution of activities (Source: created by authors).

The greatest number of people participated in walking and sightseeing, with these activities accounting for more than 15%, which is very consistent with the original intention of Olmsted to allow people to derive pleasure through the landscape's guidance. The description of sightseeing in the comments was not only related to the landscape elements, such as "I spend over an hour watching squirrels and administering the view", but also referred to the perceptions the tourists had—"You can just watch the sunset over the Skyscrapers and be in the park in silence". In the comments about walking, descriptions were given of walking places, such as "We walked from the Upper East Side, past the reserve . . . to the West side of the park". Descriptions of time were also given—"Had a beautiful autumn walk". At the same time, there were also some emotional expressions, "we were glad we camera to walk around". The next highest level of participation was found for eating, at 8.33%, of which picnicking in the park and eating in nearby restaurants were the two most important forms. The next most highly favored activity was to relax in the park, at 7.51%. The beautiful environment of Central Park allowed tourists to fully immerse themselves in it, away from the noise of the city—"Central Park has it all. If you are traveling to NYC it is the place to see". Olmsted preferred carriage travel (3.98%), horse riding (3.21%), rowing (2.83%) and skating (2.49%). Now, these are forms of paid entertainment in the park, and they also experienced a certain degree of participation—especially taking carriages. Many tourists used carriages as a means of transportation to visit the park. There were both positive comments on such activities, such as "carriage rides taking people through the park was beautiful to see", and negative comments on prices, such as "Horse and Carriages are expensive $4 a minute".

In terms of sports activities, biking was the most popular, accounting for 8.03%. Tourists generally believed that cycling was a better way to visit the whole park—"We rode bikes which were so much fun and a must for at least half your day as the park is BIG!". Running participation accounted for 3.47%. Most comments were positive, such as "Wonderful place to run". However, running was prohibited by Olmsted in the initial design of the park. In addition, marathons are often held in parks, and the tourists' comments indicate that Central Park is very suitable for marathon activities—"I can't image a more beautiful place to come across the finish line of the NYC Marathon than in Central Park". Some daily sports activities, such as exercise (0.54%) and ball games (0.93%), also featured to some extent. Although participation in swimming (0.09%) and rock climbing (0.44%) was low, the evaluations were positive—"My girls loved climbing on the rocks and seeing the family landmarks from movies", and "Swimming at Ladder Risk in the summer, and you can enjoy the park with nothing to do".

Group activities were sporadic, and the overall participation rates were low. Among these activities, the participation rates in concerts and performances (1.4%) and singing and dancing (1.63%) were relatively high—"We were highly promoted by the number of nooks where folk would aggregate to play music or dances or dance". Other group activities, such as gatherings (0.26%), political activities (0.27%), religious activities (0.11%) and weddings (0.20%), were not highly attended, but they did feature. This shows that Central Park is a place with strong inclusiveness, and different activities are undertaken in the park—"It can provide you with most any activity".

In terms of the entertainment activities, the participation levels were more uniform. Among them, shopping (3.09%) featured most highly. Tourists like to buy souvenirs and snacks at roadside stalls. In addition, every year from Thanksgiving to Christmas, there is a Christmas market in the park, with a very strong holiday atmosphere. Travelers can buy all kinds of things, and generally have very positive thigs to say—"The popup Christmas market was really big with lots of different items for sale". The participation rate in entertainment games (3%) was also high, and the evaluations were also very good—"We have masses of games and is a great place to warm up". Visiting zoos and aquariums (2.24%), and watching movies and plays (1.87%), are activities newly introduced by park managers during the decline of the park in the 20th century, and they are still enjoyed to a certain extent today.

In short, Central Park is an inclusive place where most people can enjoy themselves. Due to differences in gender, age, and other characteristics, different tourists had different preferences for activities. Studies have shown that women are more likely to be interested in picnics, horse riding and park sightseeing, while men are more likely to participate in mountain biking, rock climbing and horse riding. Compared with the elderly, young people prefer high-intensity sports activities, such as rock climbing and mountain biking [29]. For the park's designers, it was important to create an environment suitable for different people's favored activities. For example, flat sidewalks and fitness equipment are very important for sports activities in the park, while catering facilities and cafes are important for social activities [30].

4.3. Analysis of Tourists' Perceptions

The tourists' perceptions of the park are shown in Figure 7. The results show that among Olmsted's expected perceptions, the park was mostly "picturesque" and "healing". Among other feelings, the positive evaluation of "fascinating" was cited the most, followed by the evaluation of the park as "funny".

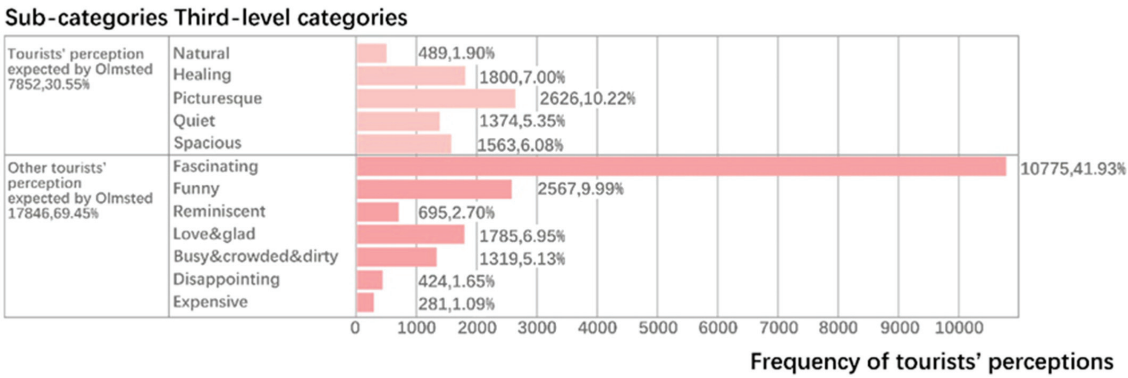

Figure 7. Distribution of tourists' perceptions (Source: created by authors).

Among Olmsted's expectations, the proportion of people who thought that the park was "picturesque" was the largest, reaching 10.22%. The comments mainly focused on the overall view of the park—"Everything is picturesque" and "I had no idea the park was this picturesque". Secondly, the park was considered "healing", "spacious" and "quiet", accounting for 7.00%, 6.08% and 5.35% of evaluations, respectively. The beautiful landscape of the park allows people to escape from the hustle and bustle of the city—"It's a safe and peaceful place to get away from the hustle and slow down and enjoy the scene". It was also seen as a kind of healing space for New York City—"This is how NY gets back to face and hearing from all the hustle and bush in the city". Finally, the park was evaluated as "natural", accounting for 1.9%. Central Park is considered an oasis in New York City—"Visited here in November and was blown away by the natural beauty of this park".

"Fascinating" accounted for the largest proportion of comments, at 41.93%. These evaluations contained a series of positive words, such as "great, wonderful, amazing, awesome, fame, popular, gorgeous, charging . . . ". This comprehensive evaluation of the park shows that the overall perception of Central Park is good. Tourists also used words such as love and happy (6.95%), fun (9.99%) and reminiscent (2.70%)—"Row the boat! Romantic and fun experience!", "The park has so many intelligent and movie memorable places within . . . so glad we came here". Here, the description of "fun" is beyond Olmsted's expectations, being cited via words such as "exploring, adventurous, intruding, interesting, fun, attractive, magnetic, characteristic . . . ".

In addition, negative comments accounted for 5.13% overall. Tourists thought that the environment of the park was dirty and messy—"It was altogether dirty and fluent with rush". The second-most common was "disappointing", accounting for 1.65%, and this view was mainly related to the maintenance and management of the park environment. "Central Park was a little dismantling. A little run down with a lot of grey instead of the lush green I was used to". In addition, a few of the assessments mentioned that the park was expensive (1.09%), mainly because of such features as the carts in the park.

4.4. Analysis of the Relationship between Tourists' Focus on Landscape Elements and Activities

The relationship between tourists' focus on landscape elements and activities is shown in Figure 8, where the thickness of the lines represents the intensity of the correlation. The results show that Olmsted's envisioned activities (walking, sightseeing, relaxing and enjoying, and eating) had the highest correlation with the landscape elements (waterscapes, views, and trees) mentioned in his design theory, followed by biking and running in terms of sports activities. Among other landscape elements, animals, sculptures and playgrounds were the most relevant to activities.

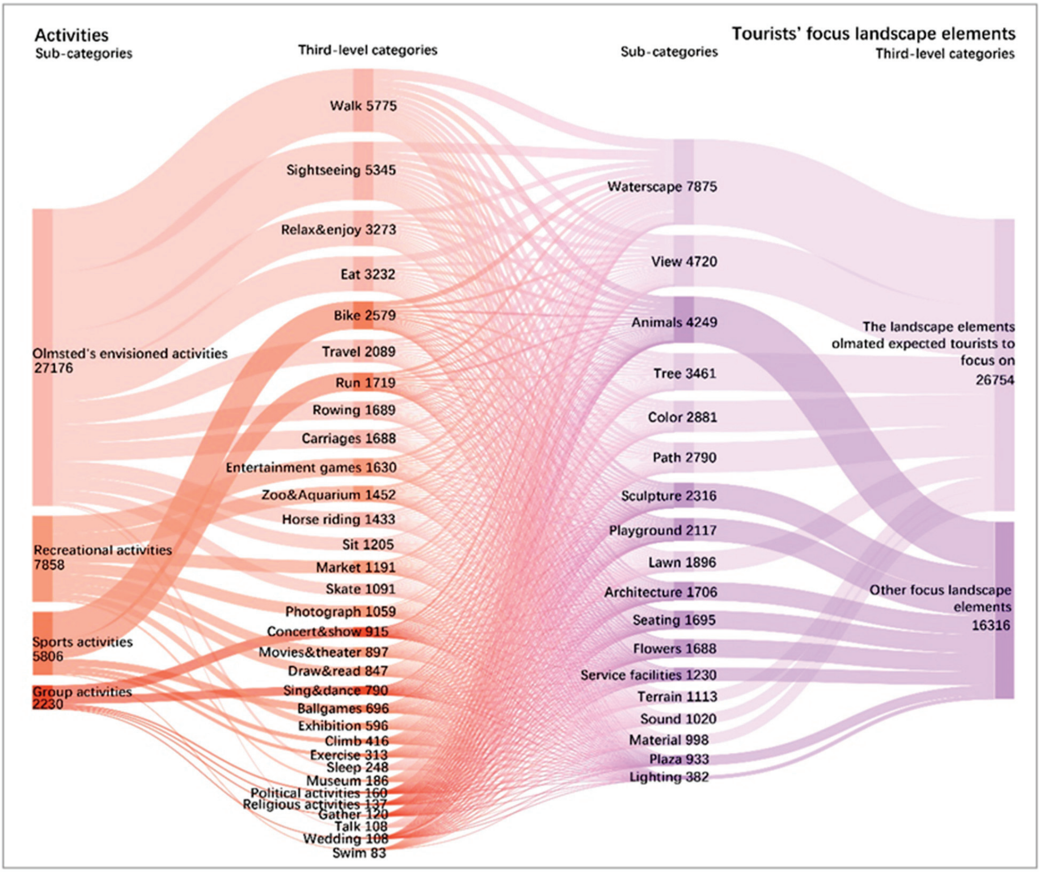

Figure 8. Sankey diagram of the relationship between the favored landscape elements and activities (Source: drawn by authors).

Among the landscape elements expected by Olmsted to be important, waterscapes were seen as the most relevant to activities. In the comments on the waterscape, 1014 mentioned "walking", 939 mentioned "sightseeing", 685 mentioned "eating", and 519 mentioned "relaxing and enjoying". The well-designed waterscapes could stimulate activities in the park, and people were more likely to pay attention to the waterscape when carrying out certain activities. The lake was a place that people often chose when rowing, eating, walking, skating, or undertaking other activities, "so many places to see so many different experiences Boating, eating by the lake and walking around to see the beautiful scene". The exquisite fountains were also considered good spots for tourists to rest and enjoy the scenery. These became the most attractive scenic spots in the minds of tourists, "Bethesda Fountain attracts my attention most. I come here every time". Next, the overall view of the park was also relevant to the activities. When "walking" (671), "sightseeing" (632) and "relaxing and enjoying" (427), tourists pay attention to their view of the park. "Spend hours walking around. Breaking taking views day and night". In this beautiful environment, it was easy for tourists to unconsciously participate in more activities, and partake in quiet entertainment in the picturesque scenery. Trees were also closely related to specific activities. The tree-lined paths were places in which people could enjoy the beautiful scenery and walk—"Plenty of beautiful park views as you walk through tree lined paths". The big trees in the park were also ideal places for people to relax and enjoy—"I find that just being amongst the towering trees and the beautiful foliage revitalizes me and brings me peace and grounds me".

Among the other landscape elements, animals were the most relevant to the chosen activities. Of the comments on animals, 608 were related to "walking", 572 to "sightseeing" and 313 to "enjoying and relaxing". As a living element of the park, they easily attracted tourists' attention. Sculptures, playgrounds and other artificial facilities were also highly related to activities. This shows that the park needed not only a picturesque static landscape, but also diverse facilities to increase interest and enrich people's activities in the park, and to enhance the interactions between people and the landscape, as well as between people.

In actual design, designers should coordinate plants, buildings, terrain changes and the proportion of water, as well as balance the relationship between natural and artificial elements, and consider more activities and interactions to offer people a rich range of emotions [31].

4.5. Analysis of the Relationship between Tourists' Focus on Landscape Elements and Perceptions

The corresponding relationships between tourists' focus on landscape elements and their perceptions are shown in Figure 9. The results show that the landscape elements (waterscape, view, trees) described by Olmsted could stimulate tourists' perceptions more effectively. Among all the perceptions, "fascinating" was the most relevant positive evaluation, followed by "picturesque", as Olmsted envisioned, and then "fun". Among other elements, animals, sculptures and flowers were the most relevant to perceptions.

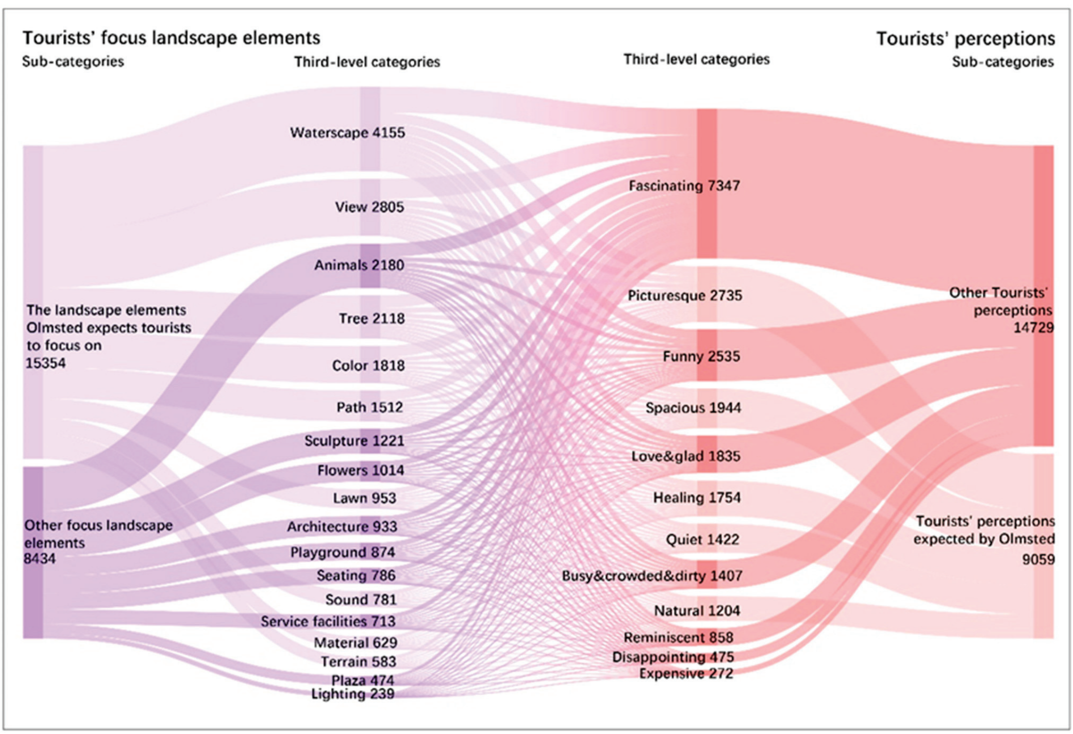

Figure 9. Sankey diagram of the relationship between focus on landscape elements and tourists' perceptions (Source: created by authors).

The waterscape had the highest correlation with tourists' perceptions among the landscape elements mentioned by Olmsted. In total, 1289 comments about waterscape were related to "fascinating", 499 comments were related to "picturesque", and 182, 244 and

268 comments were related to “spacious”, “quiet” and “healing”, respectively, followed by other perceptions, such as “love” and “fun”. The waterscape occupies less than one fifth of Central Park, but it can offer tourists completely different perceptions. Some studies have also found that the waterscape can help people to decompress and relax, and improves the recoverability of the environment [32]. Aside from the waterscape, the overall view of the park, which Olmsted attached great importance to, had the highest correlation with tourists’ perceptions. There were 357 comments related to the park being picturesque, as Olmsted expected, and others related to it being “fascinating” (983) and “fun” (289). Trees were also highly correlated with perceptions. More plants could bring induce positive emotions in people [32]. People who visit green spaces with higher plant diversity are happier [33]. The abundance of plants injected more vitality into the park, and the tourists in the park—“Love this beautiful park filled with amazing trees and plants and full of great energy. Amazing to see the city skyline behind all the greenness. The oxygenation of the city by all the wonderful green plants were important!”.

Among the other elements, animals were most relevant to tourists’ perceptions, and were highly related to descriptions of “fascinating” (659), “picturesque” (232), “fun” (226), “spacious” (184), “love/glad” (176) and “healing” (176). In addition to the wild animals in the park, the zoo was also very popular. It has become a must-visit attraction in Central Park—“Just wow, don’t ever miss it and the zoo is just awesome, it’s worth it”. Cameron showed that urban green space with higher biodiversity are associated with more positive emotional responses [34], and a diversity of birds will reduce people’s anxiety, depression and stress [35]. Sculptures also induced in tourists a variety of perceptions. There were 651 comments related to “fascinating”, 237 comments related to “picturesque” and 242 comments related to “fun”, which all made the scenery more completed, charming and interesting. In addition, Olmsted thought that the flowers and artificial elements, which should be reduced as far as possible, would also be strongly related to tourists’ perceptions.

4.6. Analysis of the Relationship between Activities and Tourists’ Perceptions

The relationship between activities and tourists’ perceptions is shown in Figure 10. The results show that most of the tourists’ perceptions are related to the unconscious and peaceful activities (walking, sightseeing, relaxing and enjoying) that Olmsted expected would feature in the park, followed by recreational activities and sports activities. The positive evaluation of “fascinating” had the highest correlation with people’s activities, followed by “picturesque” and “fun”.

Among the activities expected by Olmsted, walking was the most closely related to tourists’ perceptions. “Fascinating” (3214) was the most relevant to walking, followed by “picturesque” (1143) and “fun” (946). When walking, tourists could immerse themselves in the beautiful scenery of the park and unconsciously reach a relaxed state. When sightseeing, they most commonly experienced the perception of “fascinating” (2980), followed by “picturesque” (1001) and “fun” (982). These data show that Central Park not only achieved the tranquil, “picturesque” effect expected by Olmsted, but also brought induced exciting landscape perceptions in people through the maintenance and transformations undertaken by later managers. The activities of relaxing and enjoying were also closely related to perceptions of “fascinating”, “picturesque” and “fun”, with 1615, 548 and 543 comments, respectively. Walking, sightseeing, relaxing and enjoying tranquility in the park are beneficial to health, particularly for the eyes, thanks to the refined and rarefied air produced by the greenery [36].

In terms of entertainment activities, entertainment games and shopping were closely related to perceptions. In terms of sports activities, biking was most closely related to tourists’ perceptions, with 1524 comments related to “fascinating”, 521 related to “fun”, 480 related to “picturesque”, and 362 and 361 related to “spacious” and “healing”, respectively. Besides this, the playing of musical instruments, singing and dancing, which had been prohibited before, also induced more positive perceptions in tourists.

Now, the park is full of activities and vitality—"This park had it all, nature, museums, activities, concepts, rowing, running, every sport imaginable, vendors and much more, now go really explore it for yourself and have fun—it would probably take an entire week to see it all".

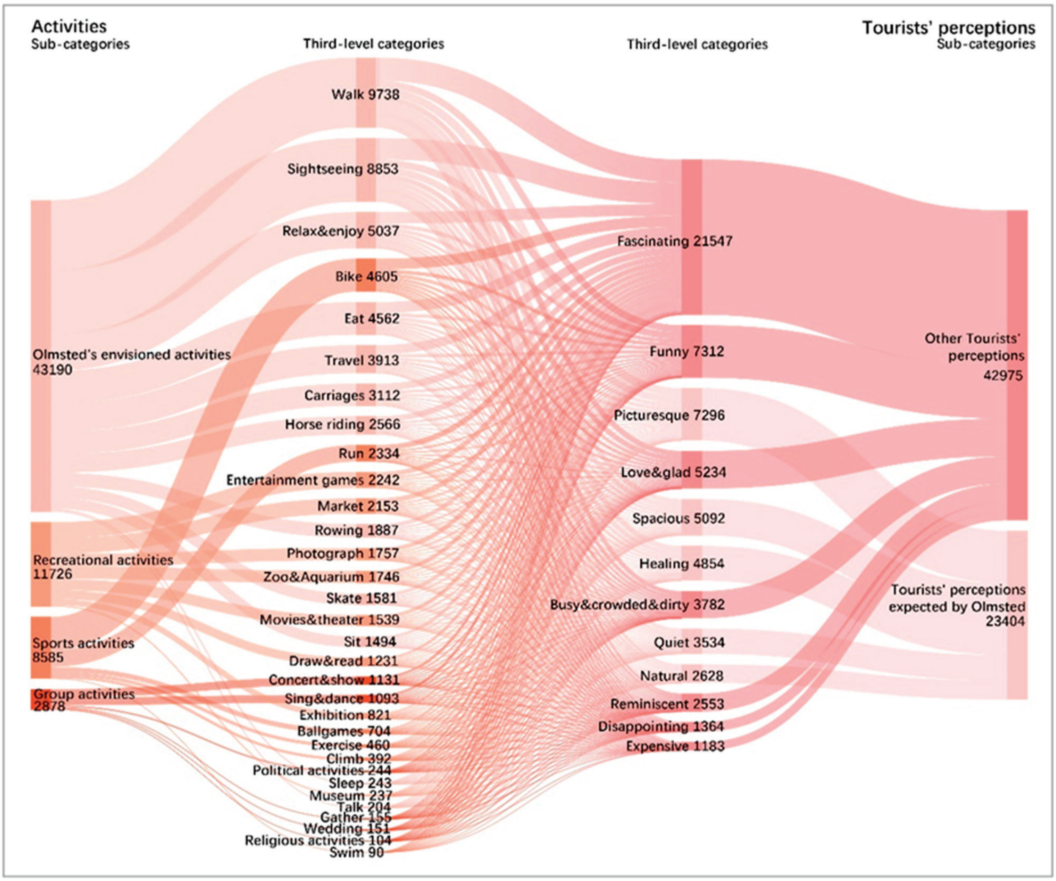

Figure 10. Sankey diagram of the relationship between activities and tourists' perceptions (Source: created by authors).

5. Conclusions

At present, the most featured elements are still those that Olmsted expected in the park, accounting for 65%. However, artificial elements and animals in the park received about 35% of the attention, which he personally opposed, or at least did not expect, at the beginning. Most of the sculptures in the park have certain culturally representative and symbolic meanings. People's attention to them reflects their attention to the history and culture of the park, and of New York itself. Sculptures have also become powerful mediums through which Central Park can promote cultural inclusiveness. People pay more attention to buildings, lights, etc., which may also be due to the upgrading of facilities and technological progress, making these elements more diversified. Flowers and animals add color and potency to the harmonious and picturesque landscape, making it more dynamically beautiful, which exceeded Olmsted's expectations.

The number of dynamic activities mentioned in the park comprised nearly 35% of all activities, which is far beyond Olmsted's expectations, and does not conform to his original intention that "the park was designed to enjoy scenery rather than entertainment".

The selling of items, running, playing of musical instruments and performing of activities that he banned at the beginning are also frequently seen in the park now, which induces in tourists a variety of perceptions. The activities he once allowed, such as horse riding, carriage riding and skating, which were considered means of transportation, have now become popular entertainment and sightseeing activities in the park.

Olmsted's expectations of "quiet", "spacious", "healing" and "picturesque" accounted for about 30% of those seen here, which shows that the park scenery could still bring tourists a soothing feeling. Now, though, the most popular comment made by tourists is "fascinating", which is a dynamic emotion, representing a strong recognition of the park. This goes beyond Olmsted's expectations. It shows that in the eyes of tourists, the beauty of modern parks lies not only in the picturesque static beauty that Olmsted expected, but also in the dynamic beauty of interesting entertainment activities and excited crowds. New York Central Park can attract a large number of tourists every year. In order to develop tourism moderately and not damage the quality of life of the local people, it should balance the activities of the four seasons. For seasonal large-scale gathering or sports activities, it should make arrangements and subordinates in advance to avoid overtourism [37].

Overall, Olmsted's design theory had a broad cross-generational vision that may have inspired the current park design. He believed that establishing a connection between people and nature can restore people's physical and mental health. This view was forward-looking, and had a subtle influence on the design of the current park. He recognized the important role of parks in healing urban populations, and this remains an integral value of urban parks. At the same time, one of the main reasons Central Park came back to life after so many twists and turns is that it has been flexible and accommodating enough to be redefined to meet the needs of social aesthetics, urban development, and people in different times. New York's Central Park is not a giant green isolated island in Manhattan, but an urban oasis of great public and social significance, which plays a vital role in the health of New Yorkers, and of New York City itself. It is not only part of the precious heritage left for us by Olmsted, but also the most famous and successful urban park in the world today, as well as a model of modern urban parks. The great influence of his practical works and design theory on the landscape architecture discipline, and on the whole of modern society, were not to be surpassed or even copied until many years later.

Big Data was used as a research tool, and tourists' post-occupation comments on the park were used as a data source to understand their preferences when in Central Park. The broad data collected directly recorded the elements, activities and perceptions of the park that they focused on. Comparing these data with Olmsted's design theory, and adding some reviews by modern scholars describing the park preferences of people, a conclusion could be obtained about the extent to which Olmsted's ideological heritage has been preserved today. At the same time, big data can also be used as a tool to improve the tourist experience. Through the big data platform, new tourist destinations can be found, the number of tourists or the surrounding hotels and restaurants can be queried, and the right time has been chosen to travel to avoid overtourism [37].

Our results also provide detailed guidelines for the design of natural landscapes and man-made structures, which are closely related to the field of landscape design [38]. This can help identify the content that needs to be improved in the early and late maintenance periods of modern park design, and in this way, more attractive and inclusive parks could be designed for contemporary people. Based on the results of this study, some suggestions could be made regarding the construction of modern urban parks: (1) In terms of landscape elements, users pay more attention to the waterscapes, animals and trees in the park, and to the overall appearance and colors of the park. At the same time, all elements should work together as in a beautiful landscape painting, with coordinated colors and composition. (2) Walking, sightseeing, and other static activities are the most popular. Plants, waterscapes, terrain and other elements can be used to create a suitable space and atmosphere during design. (3) Well-designed elements can promote tourists' activities in the park. In turn, people will be more likely to notice said landscape elements when they participate in activities. Elements and activities reflexively stimulate each other, offering tourists a rich experience of the park. Compared with the landscape elements of the park, the activities performed in the park can affect the moods of tourists more significantly, and tourists pay more attention to their personal participation in and interactions with the park.

In later research, multi-source data such as those derived from Instagram or remote sensing could be combined, and on-site research can be carried out at the same time. In this way, more research directions can be opened up, on a wider range of sites, or with the combination of microclimate and Big Data. In addition, data with a longer time span could be used to explore whether people's entertainment experiences in the park change with time or the development of social events, such as epidemics.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/buildings12122217/s1, Table S1: Word frequency table; Table S2: Table of relationship between activities and landscape elements; Table S3: Table of relationship between landscape elements and perceptions; Table S4: Table of relationship between activities and perceptions.

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Article

Analysis of the Spatial and Temporal Distribution and Reuse of Urban Industrial Heritage: The Case of Tianjin, China

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Abstract: Urban industrial heritage is both a physical component of the city and an important carrier of urban memory, but there is still a lack of comprehensive analysis of industrial heritage in Tianjin and a need for a conservation system. This study took the industrial heritage of Tianjin built between 1860 and 1978 as the research object and used GIS technology to analyse the spatial and temporal distribution of industrial heritage and the current state of its reuse. The results show that in the temporal dimension, the distribution of industrial heritage in Tianjin shows a pattern of change of "gathering first, then scattering", with the 1960s as the time point; in the spatial dimension, the existing industrial heritage shows a pattern of distribution along important transport routes—the Haihe River, the Jingfeng Railway and the Jinpu Railway, and there are three industrial heritage clusters. The conservation and reuse status of industrial heritage varies by resource type, but the overall state is poor. Based on the results of the above analysis, a holistic conservation concept of the "Tianjin Industrial Heritage Route" and a reuse strategy for different resource types of industrial heritage are proposed. This will help to integrate the reuse of Tianjin's industrial heritage into the sustainable development of the city and provide a reference for the conservation of industrial heritage in other cities in China and even in the world.

Keywords: urban industrial heritage; spatial and temporal distribution; heritage reuse; heritage census; Tianjin city

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1. Introduction

In 1986, industrial monuments were added to the World Heritage List. As a testimony to the development of human civilization and cities, industrial monuments such as ancient palaces, cities and temples have become important for carrying the history of mankind and a cultural legacy of human history [1]. Judging from the trend of international heritage conservation, large-scale, cross-regional linear cultural heritage is receiving more and more attention [2]. At the end of the 20th century, the United States and Europe put forward the ideas of the "heritage corridor" and "cultural routes", which are regional scales for the conservation of industrial heritage [3,4]. In Europe, the European Route of Industrial Heritage (ERIH) was created in 1999 to support the development of industrial heritage tourism routes [5]. For the conservation of industrial heritage in China, although the National Cultural Heritage Administration has issued the *Wuxi Recommendations* on industrial heritage conservation in 2006, heralding the rise of research and conservation of industrial heritage on a national scale [6–8], in concrete conservation practice, the existing legal system and policy and institutional framework for conservation and use remain the same as when they started in 2006 [9,10], and the research and discussions are still dominated by individual cases. The reuse of industrial heritage is also focused on the factory and building level [11–13]. On the whole, policies, research and practices related to industrial heritage remain on a case-by-case basis, and there is a lack of both comprehensive analysis and the construction of conservation systems of industrial heritage at the regional level [7,8].

Recently, the application of GIS in the field of heritage conservation has been expanded to include cultural resource management [14–17], heritage monitoring and restoration [18–20] and other aspects. In addition, the research method of applying GIS technology to analyse the spatial and temporal distribution of cultural heritage is widely used [21–24]. The above GIS development directions also provide new ideas for the conservation of industrial heritage. As a geographical information platform, GIS can visualise the distribution of industrial heritage into urban territorial space and use it as a basis for a more objective analysis of the characteristics related to the spatial distribution of industrial heritage in the city using GIS tools. At the regional level, the use of GIS technology to analyse the spatial and temporal distribution characteristics and the conservation and reuse status of industrial heritage at the regional level can help to improve the comprehensive and scientific understanding of industrial heritage in a region, while providing a wider source of information and more scientific analysis results for conservation decisions in urban planning. It can also provide a reference for industrial heritage conservation in various cities. Tianjin plays an important role in China's early modern and modern history, and is known as "Tianjin witnessed one hundred years of Chinese history". [25]. In 1860, Tianjin was opened as a port and became a "nine-country concession", marking the beginning of the early modernisation process in Tianjin [26]. Since then, the construction during the Westernization Movement made Tianjin the core area of the Beiyang base [26]; the rise of private capital made the area around Haidadao Road the birthplace of national machine manufacturing [27]; the construction of the "nine-country concession" and the implementation of the New Deal at the end of the Qing Dynasty brought about an industrial boom in the Sancha River estuary area [28]; and Tianjin became a rear base for the Japanese invaders after the fall of Tianjin at the beginning of the War of Resistance Against Japan [28]. Before the founding of the People's Republic of China, Tianjin was the industrial centre of northern China, and thus left behind many outstanding industrial legacies [29]. After the founding of the People's Republic of China, Tianjin's industrial status declined and industrial construction began to develop in the hinterland in the context of the "Third Front Movement" [30,31]. The steady development of modern industry in Tianjin still left a certain amount of industrial heritage in Tianjin [32]. Tianjin's industrial heritage is characterised by its early age, important status, richness of types and distinctive spatial distribution [29]. The history of Tianjin's growth is that of the "northern economic centre" [33]. There have been some achievements in the study of Tianjin's industrial heritage as a whole, such as the identification and classification of the scientific and technological value of Tianjin's industrial heritage [34], the composition and characteristics of Tianjin's industrial heritage groups [35] and the construction of Tianjin's industrial heritage corridor system [36], but a systematic and quantitative analysis of Tianjin's industrial heritage is still lacking. The research object of this paper is the industrial heritage of Tianjin from 1860 to 1978. Using GIS technology, we analysed the spatial and temporal distribution characteristics of Tianjin's industrial heritage and the conservation and reuse status of various types of industrial heritage, so as to provide a quantitative data basis for the regional conservation of Tianjin's industrial heritage. The urban industrial heritage, as the material foundations of the city, often occupies a prime location and a large space in the city [37,38], and it is an important aspect of sustainable urban development to make efficient use of its existing derelict physical space for future use, rather than adopting a "large-scale demolition or construction" model.

2. Data Sources and Research Methods

2.1. Data Sources

The data were derived from the results of "Comprehensive Census of Industrial Heritage in Tianjin". The census was commissioned by the Tianjin Municipal Bureau of

Planning (merged into Tianjin Municipal Bureau of Planning and Natural Resources in 2018), and the process and results were monitored and checked. The team collected relevant historical information to establish a list of factories and related facilities that existed historically within Tianjin. There are two sources of original material, one from the relevant archival materials in the Tianjin Municipal Archives and the National Library of China, and the other from relevant works and papers, such as: *China's Early Modern Industrial History Data* (Jingyu Wang), *The History of Modern Chinese Industry* (Cishou Zhu), *Tianjin Historical Materials* (Institute of History, Tianjin Academy of Social Sciences), *History of Railway Development in China* (Shixuan Jin and Wenshu Xu), *Tianjin Urban Planning Records* (Tianjin Urban Planning Journal Compilation Committee), *A Brief History of Urban Construction in Tianjin* (Hong Qiao) and *Inestigation on Tianjin's Modern Autonomous Industrial Heritage* (Hong Ji). Due to the lack of documentation on the state of preservation of the listed factories in recent years, more than 20 PhD and MA students were organised to conduct on-site research based on the list between 2010 and 2012, after which the research was systematically collated. The methods used for the research included: GPS geographic information acquisition, building mapping, photographic documentation, heritage overview documentation, conversation status documentation, primary source material acquisition and interviews with relevant people.

The census work used the unified "Tianjin Industrial Heritage Survey Form" (Table S1), which was divided into the "Tianjin Industrial Heritage Buildings/Structures Survey Form" and the "Tianjin Industrial Heritage Plants Survey Form", the executive summary of which is shown in Table 1. In terms of the temporal scope of industrial heritage, the development of Tianjin's modern industry was combined with studies related to China's industrial development [39,40]. The opening of Tianjin in 1860 marked the beginning of modern industry in Tianjin [26], and after the Third Plenary Session of the Eleventh Central Committee in 1978, China's industry entered a new stage of rapid development, but because it is relatively recent, the industrial heritage built after 1978 has received less academic attention, and only very little is known in the country [41]. The time frame of the industrial heritage surveyed was therefore limited to the period 1860–1978, and the definition of industrial heritage was based on The Nizhny Tagil Charter and the Taipei Declaration for Asian Industrial Heritage [42,43].

Table 1. Synopsis of the Tianjin Industrial Heritage Survey Form.

Classification	Content
Buildings/structures Survey Form	building number, building name, individual floor area, number of storeys, building height, date of construction, original function and change of use, restoration and renovation (age/content), number of current photographs (including facade, interior, details), quality of building, condition of equipment, value of building, conversation strategy
Plants Survey Form	original name, current name, designer, address, scoping of the site, date of foundation, location of remains, historical floor area, area of the site, unit of ownership, original use, current users, current type of use, historical evolution, whether the site is being planned, mode of conservation and reuse, environmental elements (vignettes, sculptures, original fences, old and valuable trees), others

The Tianjin Industrial Heritage Census took two years to complete, and at the end of 2012, a total of 120 items of industrial heritage had been identified during the census. Subsequently, based on the census results, the group conducted regular follow-up surveys of Tianjin's industrial heritage, which was finally identified as 111 items as of June 2020 due to the demolition of factories caused by urban development and construction.

2.2. Research Methods

The research process of this paper was to import the data of base map elements—such as the Tianjin city area, boundaries of districts and counties, and major rivers, railways and roads; and the data of industrial heritage sites obtained from the above census in GIS format. Based on this, the analysis tools in GIS software—kernel density tool, mean centre tool, standard deviation ellipse tool and buffer zone tool—were used to generate the corresponding analysis maps (Figure 1). The kernel density analysis can visualise and abstract the overall distribution of industrial heritage in Tianjin at different periods and facilitate comparison of changes between periods. The standard deviation ellipse tool can analyse the strength of agglomeration and changes in agglomeration areas of industrial heritage at different periods. Mean centre analysis can determine the centre of gravity of industrial heritage and its movement trend at different periods. The buffer zone tool can analyse the trend of distribution of industrial heritage along major transport routes in Tianjin. In this process, GIS firstly provided a platform for overlaying the two types of data mentioned above, and secondly, the various analysis tools included in GIS helped to visualise the results more accurately and quickly, preventing the process of calculating the results from formulas and then converting them into images and providing easy conditions for the verification of such results.

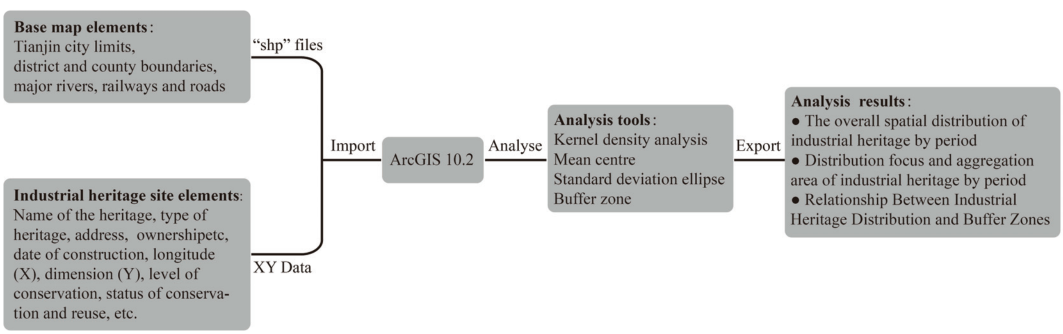


Figure 1. Data analysis process.

2.2.1. Kernel Density Analysis

Kernel density estimation. The kernel density function was used to correlate industrial heritage sites in Tianjin for probability estimation. Based on the kernel density estimation, it is possible to distinguish the spatially distributed areas of concentration of industrial heritage in Tianjin in different dimensions, such as time and type. The function is expressed as a bivariate probability density function whose value in space is centred on a known point and tends to zero over a range of widths. The Rosenblatt–Parzen kernel density estimation formula is commonly used [44].

$$R(x) = \frac{1}{nh} \sum_{i=1}^{n} k\left(\frac{x - x_i}{h}\right) \quad (1)$$

In the formula, $R(x)$ is the probability value of element R at x. In this study, R is the industrial heritage site. $k\left(\frac{x-x_i}{h}\right)$ is the kernel function, where $(x - x_i)$ is the distance from the estimated value point x to the industrial heritage site x_i; h is the bandwidth and is greater than 0. Studies have shown that the kernel function has a minimal effect on the results and h has a large effect, and there is no authoritative formula for determining the value of h. The author determined the value of h to be 1 km based on several experiments.

2.2.2. Mean Centre and Standard Deviation Ellipse Analysis

The migration of the spatial coordinates of the mean centre in different periods can characterise the trend of change in the spatial distribution of industrial heritage in Tianjin. The standard deviation ellipse can characterise the main distribution range, directional trend and degree of aggregation of industrial heritage sites in Tianjin in each period. The area of the calculated range characterizes the size of the distribution range, the direction of the long axis reflects the directional trend of the distribution of elements and the short axis represents the distribution range [45,46]. Larger values of flatness indicate higher spatial aggregation. The formula is as follows.

$$C = \frac{1}{n}\begin{pmatrix} \sum_{i=1}^{n} \overline{x}_i^2 & \sum_{i=1}^{n} \overline{x}_i\overline{y}_i \\ \sum_{i=1}^{n} \overline{x}_i\overline{y}_i & \sum_{i=1}^{n} \overline{y}_i^2 \end{pmatrix}, \begin{cases} \left(x_i - \overline{x'}\right) \\ \left(y_i - \overline{y'}\right) \end{cases} \tag{2}$$

In the formula, $\overline{x}$, $\overline{y}$ are the mean centroid coordinates; x_i, y_i are the *i*-element coordinate values; and n is the total number of elements.

2.2.3. Buffer-Zone Analysis

Based on the buffer-zone widths with gradients of 0–4 km, the buffer zones were calculated for water systems, railways and other transportation elements; and the buffer zones were analysed with the overlapping distribution of Tianjin's industrial heritage site elements to generate an analysis map with the percentages of the numbers of industrial heritage sites in the buffer zones of different widths of the total. Three representative buffer-zone widths of 0.5, 1 and 4 km were selected for illustration to determine whether Tianjin's industrial heritage has a correlation with the distribution of main transport routes.

3. Results

Based on the above census results, the Tianjin Industrial Heritage Census GIS Database was established (Figure 2). The database's framework mainly includes two categories, industrial-heritage elements and base-map elements in Tianjin. The industrial-heritage elements include plant-point elements, building-point elements and structure-point elements; the base map elements include Tianjin-city-boundary elements, Tianjin-district- and Tianjin-county-boundary elements, major-river elements, major-railway elements and urban-road elements. The source of the industrial-heritage elements was the results of the Tianjin Industrial Heritage Census, and the source of the base map elements was the National Basic Geographic Information System.

3.1. The Spatial and Temporal Distributions of Industrial Heritage

According to previous studies, such as *China's Early Modern Industrial History Data* (Jingyu Wang et al.) and *The History of Modern Chinese Industry* (Cishou Zhu), and taking into account the history of early modern and modern industrial development in Tianjin, the stages of early modern and modern industrial development in Tianjin can be divided into seven phases, among which, the early modern period can be divided into: (1) the embryonic period of early modern industry (1860–1894), (2) the development period of early modern industry (1895–1913), (3) the prosperity of early modern industry (1914–1936) and (4) the decline of early modern industry (1937–1949). The modern period can be divided into: (5) initial construction of socialist industry in New China period (1950–1957), (6) the Second Five-Year Plan period (1958–1963) and (7) the Third Front Movement period (1964–1978). It should be noted that the beginning of China's early modern industrial history was 1840, whereas the development of early modern industry in Tianjin began in 1860 [26], so the first period was 1860–1894. Secondly, from an industrial history perspective, the fifth period includes national economic recovery period (1950–1952) and First Five-Year Plan period (1953–1957), but as both periods were relatively short and few industrial legacy sites remain (five and four respectively), they are combined into an initial construction of socialist industry in New China period. The number of industrial heritage sites in Tianjin was counted using the above time boundaries (Table 2).

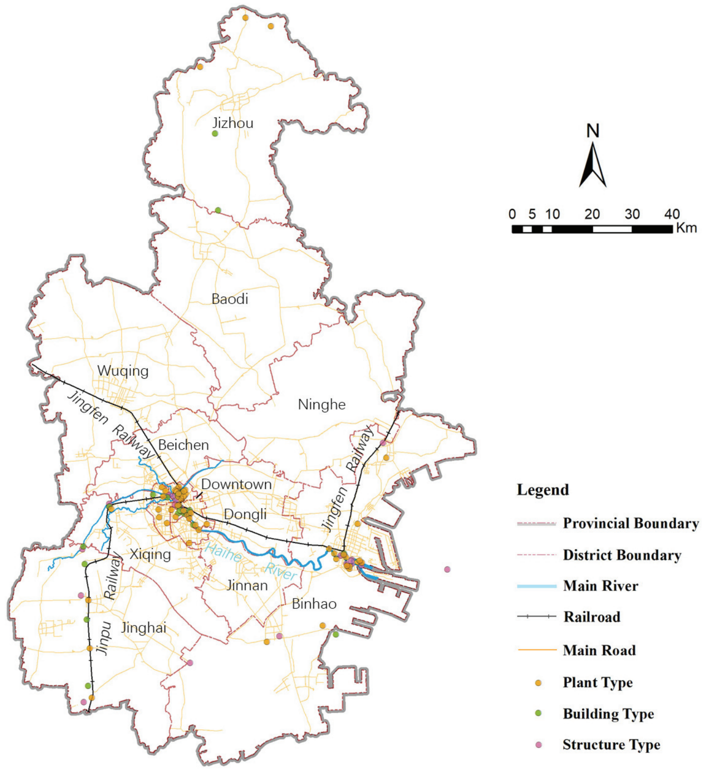


Figure 2. Tianjin Industrial Heritage Census GIS Database (base map source: National Basic Geographic Information System).

Table 2. Statistics on industrial heritage in Tianjin by historical period.

Historic Stage	Amount of Heritage	Name of Heritage
Embryonic period of early modern industry (1860–1894)	11	Gouhe River North Quarry, Dagu Rest House, British Jardine Matheson Pier, Waterline Ferry Terminal, the former site of the Qing Dynasty Post Office, former Tianjin Telegraph Office Building, Dagu Dockyard of the Beiyang Marine Division, former Tianjin Printing House, Tanggu Railway Station, Dahong Bridge, Hangu Railway Bridge
Development period of early modern industry (1895–1913)	22	Kailuan Mining Bureau Tanggu Wharf, Swire Pacific's Tanggu Terminal, the former site of Ji'an Water Supply Co., the former site of French Electric Light House, Wanguo Bridge, the former site of Haihe River Engineering Bureau, the former site of Xinhe River Railway Material Factory, the former site of Tianjin New Station, Jingang Bridge, the former site of Bishang Tianjin Trolley and Electric Light Company Limited, Tianjin General Mint, Qixin Foreign Grey Company Tanggu Wharf, Tianjin Jin Tang Bridge, Jinghai Railway Station, Tangguantun Railway Station, Tianjin West Railway Station Main Building, Tangguantun Iron Bridge, Tianjin Locomotive and Rolling Stock Factory, the former site of Xigu Machine Factory on Jinpu Road, Tangguantun Water Supply Station, Chenguantun Railway Station, Yangliuqing Railway Station Hall

Table 2. *Cont.*

Historic Stage	Amount of Heritage	Name of Heritage
Prosperity of early modern industry (1914–1936)	29	The former site of the Tianjin Daren Tang Pharmaceutical Factory, the oil depot of the Asia Kerosene Company, the former site of the Huaxin Textile Co., Xingang Engineering Bureau Machinery Repairing Factory, Yonghe Company, Yongli Soda Factory, the former site of the workhouse of Huaxin Yarn Factory, the staff residence of Danhua Match Factory, the former site of the British American Tobacco Company North Headquarters, the former Kailuan Mining Bureau building, former Jardine Matheson Building, Beiyang Workshop, Yang Gate, the former warehouse of the British firm Jardine Matheson, Er Gate, the former site of the Tianjin Lisheng Sporting Goods Factory, the British American Tobacco Company Apartments, the former Jardine Matheson building, Yellow Sea Chemical Industry Research Institute, the former site of Baochengyu Big Yarn Factory, Yongli Soda Factory Office in Tianjin, former Jiu Da Fine Salt Company Building, former Taikoo Foreign Bank Building, the former site of Tianjin Telephone Bureau No. 4, the former site of Tianjin Telephone Bureau No. 6, Jiu Da Fine Salt Company Wharf, former French Ministry of Industry and Commerce, the former site of East Asia Woolen Textile Company Limited, the former site of the East Asia Tweed Textile Co., Jiapei Iron Works
Decline of modern industry (1937–1949)	21	The former site of Shengxifu Hat Village, the former site of the Tianjin Storage and Transportation Office of the General Department of Material Storage and Transportation of the Ministry of Communications, the former site of Tianjin Electric Company Limited, the forty-fifth group of the salt factory, the Hangu Factory of Toyo Chemical Industry Co., The former site of the 3526 Factory, the former site of the Japan Concord Printing Factory, the Ning Family Compound (3522 Factory), Xingya Steel Company Limited, the former site of the Japanese Dagu Tuodi Wharf, the Provisional Construction Bureau of the New Port of Beizhina, two red brick buildings of the Tianjin Turbine Factory, the former site of the Japanese Tanggu Mitsubishi Oil Depot, the former site of the Japanese Dagu Chemical Factory, Xingang Gate, Tianjin Glass Factory, Textile Machinery Factory, the former site of the state-owned Tianjin Radio Factory, Tianjin Instrument Factory, the former site of the Beining Railway Administration, Duliu Water Supply Station
Initial construction of socialist industry in New China period (1950–1957)	9	Tianjin Meiya Automobile Factory, Tianjin Railway Engineering School, Tianjin Public-Private Partnership Demonstration Machine Factory, Tianjin Quilt General Factory No. 10 of the General Headquarters of the United Services Command of the National Government, Tianjin Brewery, Tianjin Base Materials Factory Office Building of the Ministry of Railways, Machinery Factory belonging to the Third Railway Survey and Design Institute, Tianjin Tractor Factory, the former site of Tianjin Foreign Trade Carpet Factory
Second five year plan period (1958–1963)	9	Haihe River Tide Barrier Gate, Tianjin Internal Combustion Engine Magnetic Motor Plant, Xihe River Gate, Ziya River Gate, Eleventh Castle Water Raising Station Gate, Zhengguang Water Raising Station, Chengguan Water Raising Station Gate, Tianjin Rubber Factory No. 4, Dazhuzhuang Drainage Station
Third-front movement period (1964–1978)	10	Port 5 well, Tianjin Watch Factory, the former site of Tianjin Radio War Station, Tianjin Petroleum and Chemical Fibre General Factory Chemical Sub-Factory, Dagu Lighthouse, the former site of Hexian Factory, the former site of Qianganjian Arsenal, Sanchakou Water Raising Station, Water Raising Station, Shuangwang Water Raising Station

By analysing the statistical results, a total of 111 sites of Tianjin's industrial heritage survived from 1860 to 1978, of which the main contributor is the early modern period, especially from 1914 to 1936, which is a side indication that it was the peak period of industrial development in Tianjin at that time. After the founding of the People's Republic of China in 1949, the focus of industrial development gradually moved to the inland and the southwest and northwest regions, and the importance of Tianjin diminished [30]. The number of industrial heritage sites decreased significantly, and the type shifted to mainly municipal types, such as sluices [35].

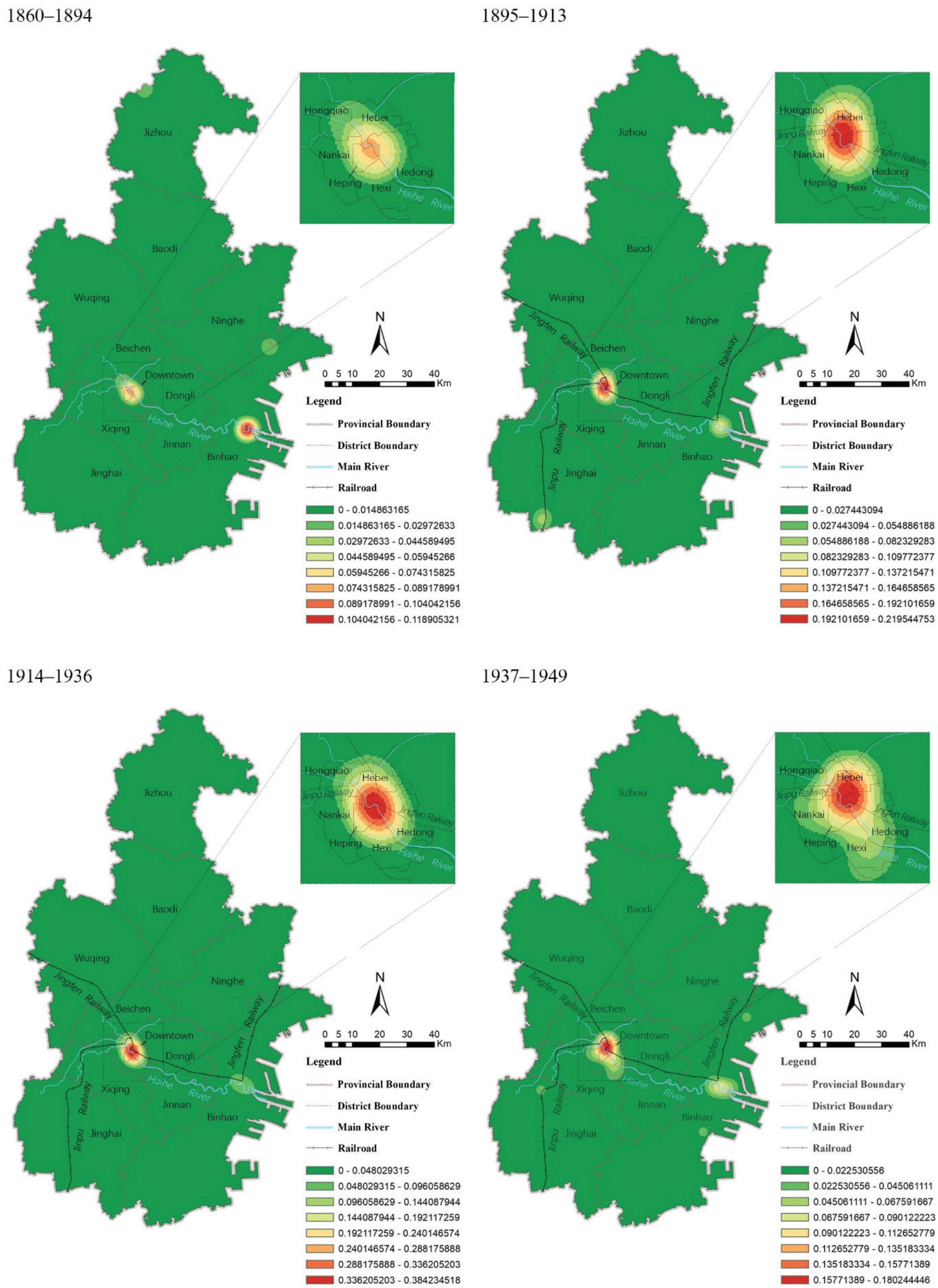
3.1.1. The Overall Spatial Distribution of Industrial Heritage by Period

The results of the kernel density analysis of industrial heritage in each era using GIS technology are shown in Figure 3. Tianjin's industrial heritage has different characteristics in different historical periods, but overall it also reflects certain patterns: during the early modern historical period from 1860 to 1949, there were three areas where the distribution of Tianjin's industrial heritage was focused: the Sancha River estuary area at the junction of Hebei District and Hongqiao District; the city centre area at the junction of Heping, Hedong and Hebei Districts; and the Haihe River estuary area in Binhai District. The first two of these areas are located in the centre of Tianjin. The other areas have a small amount of industrial heritage and show a clear dependence on railway lines, waterways and other transportation routes for construction. During the modern historical period from 1949 to 1978, the spatial distribution of Tianjin's industrial heritage began to show a trend of scattered development: from being concentrated in the six districts of the downtown to expanding to the periphery of the city, including Xiqing District, Jinghai District and Jizhou District; from the estuary of the Hai River in Binhai District to its north, west and south; and new clusters of industrial heritage emerged in northern Tianjin.

3.1.2. Distribution Focus and Aggregation Area of Industrial Heritage by Period

The spatial distribution regarding the centre of gravity and standard deviation ellipse of industrial heritage for each period were obtained using mean centre analysis and deviation ellipse analysis, respectively (Figure 4). On the whole, the centre of gravity of industrial heritage distribution in the seven periods was located roughly in the central-southern region of Tianjin, along the main transport routes of the Haihe River, the Jingfeng Railway and the Jinpu Railway. The centre of gravity shifts sharply from one period to the next and is generally within an outer circle with a radius of 15.59 km. In the three periods between 1914 and 1978, the centre of gravity of the industrial heritage is more concentrated, with a juxtaposition along the river. From the spatial evolution of the seven periods, the centre of gravity of industrial heritage shows a general trend of change from east to west and then east again.

Based on parameters such as the angle of rotation, the length of the long axis and the length of the short axis of the standard deviation ellipse (Table 3), the spatial distribution of industrial heritage in the seven periods can be divided into two intervals. In the four periods from 1895 to 1957, the ellipse is horizontally distributed, with an ellipse rotation angle range of 62.70–99.64°, a long axis length range of 20.56–32.29 km and a short axis length range of 4.12–21.66 km; in the remaining three periods, the ellipse is vertically distributed, with an ellipse rotation angle range of −16.67–16.38° (clockwise is positive), a long axis length range of 46.64–85.04 km and a short axis length range of 27.56–35.53 km. Accordingly, it can be found that when the ellipse is laid out horizontally, it is located near the Haihe River, and the ellipse has a smaller area and a higher flatness, indicating a high degree of industrial heritage concentration; when the ellipse is laid out vertically, the distribution location is not fixed, and the ellipse has a larger area and a lower flatness, indicating a low degree of industrial heritage concentration.



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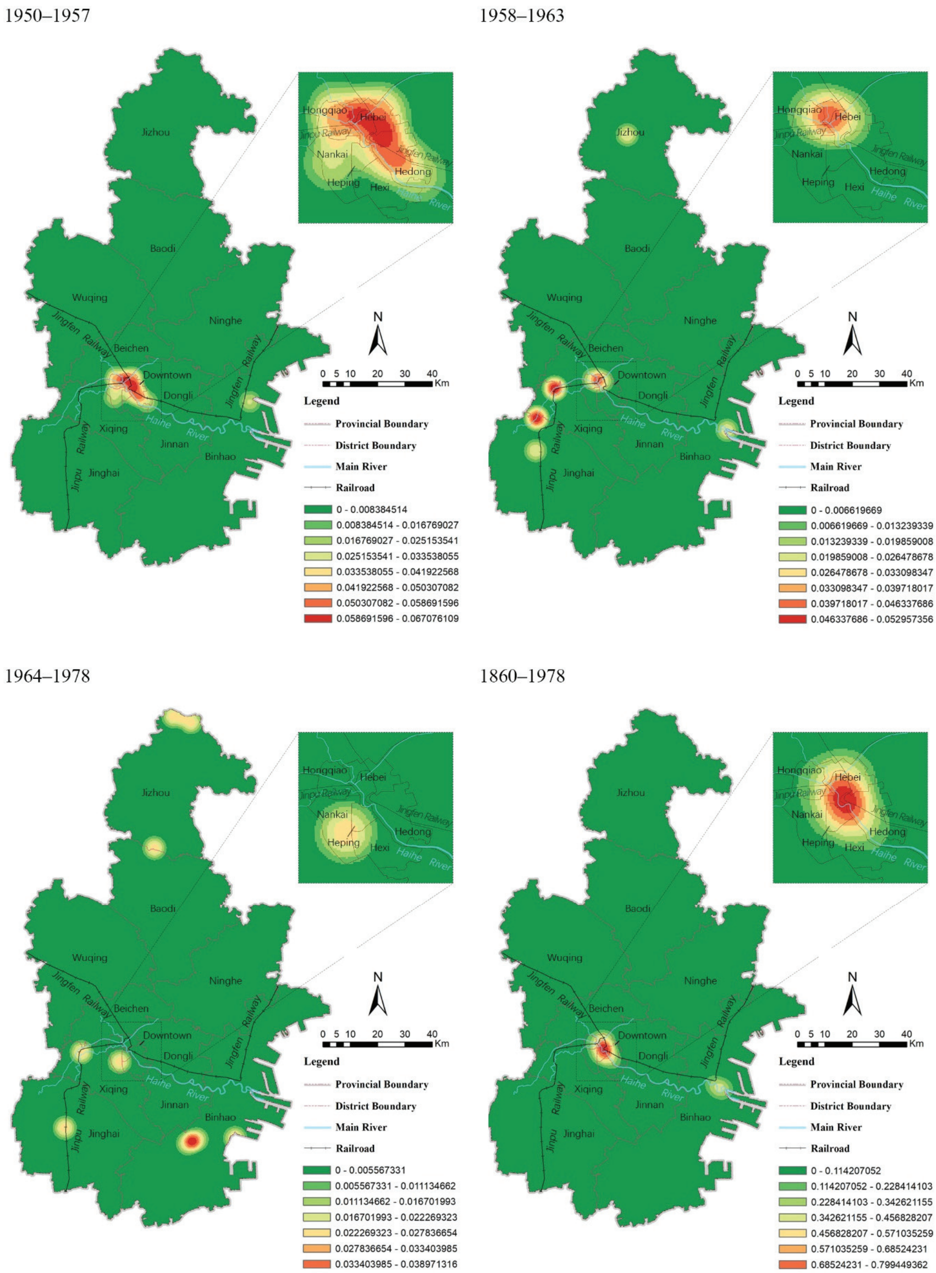


Figure 3. Distribution of kernel density by period of Tianjin's industrial heritage.

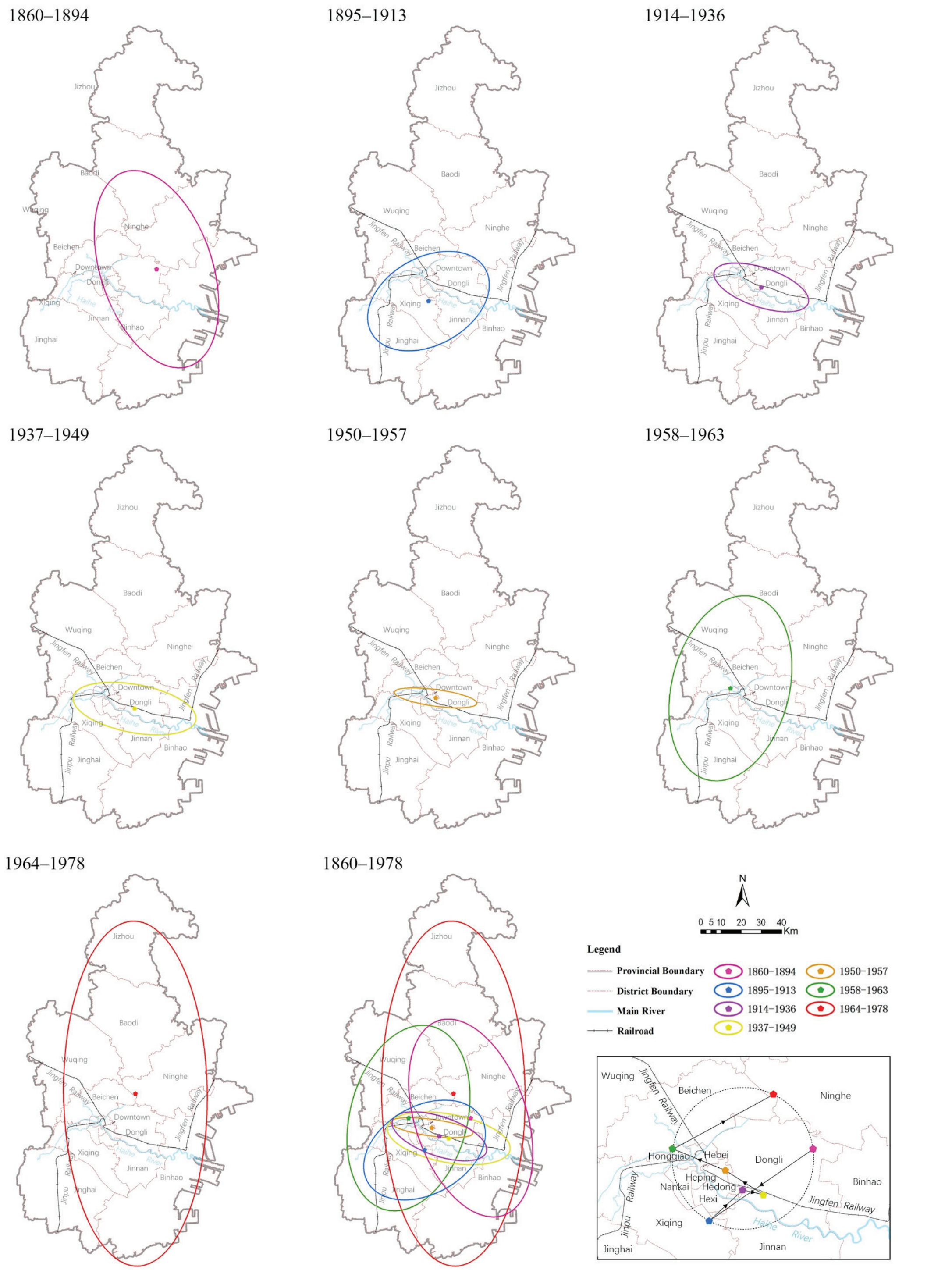


Figure 4. Spatial distribution centre of gravity and standard deviation ellipse of Tianjin's industrial heritage by period.

Table 3. Spatial distribution's centre of gravity and standard deviation ellipse parameters by period.

Historic Stage	Areal Coordinates	Directional Angle	Long Axis (km)	Short Axis (km)	Oblateness	Shape Area (km^2)	Moving Direction	Moving Distance (km)
1860–1894	117.49° E, 39.17° N	−16.67°	50.61	27.56	0.46	4382.09		
1895–1913	117.22° E, 39.04° N	62.70°	32.29	21.66	0.33	2197.03	Southwest	27.76
1914–1936	117.30° E, 39.10° N	110.46°	24.51	9.70	0.60	746.72	Northeast	10.00
1937–1949	117.36° E, 39.09° N	102.52°	30.90	11.89	0.62	1154.27	Southeast	4.71
1950–1957	117.26° E, 39.14° N	99.64°	20.56	4.12	0.80	266.04	Northwest	9.95
1958–1963	117.13° E, 39.18° N	16.38°	46.64	29.04	0.38	4254.70	Northwest	12.40
1964–1978	117.39° E, 39.28° N	1.20°	85.04	35.53	0.58	9490.88	Northeast	25.29

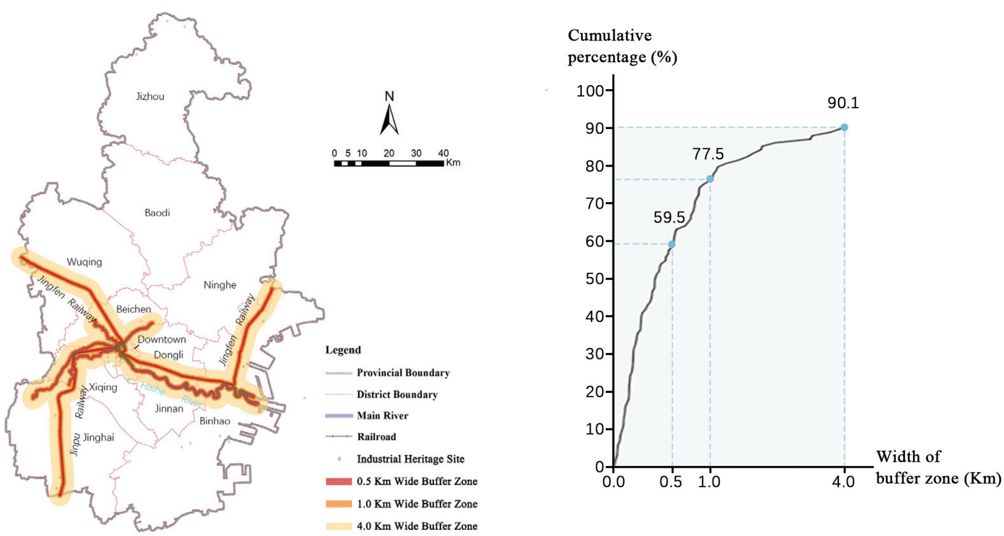
3.1.3. Analysis of the Causes of the Spatial and Temporal Distribution of Industrial Heritage

The spatial and temporal evolution of Tianjin's industrial heritage is closely related to the context in which it was built. The Tianjin Machine Bureau was built in 1866 (the fifth year of the Tongzhi era of the Qing Dynasty), starting the history of early modern industry in the city of Tianjin [26]. Thereafter, the "westernization group" established a series of military industries in and around Tianjin, which became the core area of the Beiyang base [26]. In the 1880s, private capital industries were established in the area of Hai Da Dao Road (now Dagu Road), making this area the birthplace of Tianjin's early national capital machine manufacturing industry [27]. From 1902, when large-scale construction began in the national concessions, to 1937, when it basically came to a halt, the nine national concessions gradually formed a layout that began on the north side of the Sancha River estuary and ran eastwards along both sides of the river; in the same year, Yuan Shikai took over Tianjin and implemented the "New Deal", focusing on the construction of the Hebei New District immediately east of the Sancha River estuary [28]. In the first and middle of the 20th century, Tianjin gradually became the industrial centre of North China and the second largest industrial city in the country. During the fall of Tianjin after 1937, Tianjin became a rear base for the Japanese invasion of China. The Japanese government, motivated by the demands of war, built up the industry in Tianjin, enabling the development of the Tianjin machinery industry [27]. After the founding of New China in 1949, the country's economic construction focused on the development of heavy industry as the main industry, and urban development was also aimed at industrial cities, while Tianjin was not classified as a category 1 heavy industry city and was a city with a large number of industrial key projects, and its industrial status declined [30]. In the 1960s and 1970s, China carried out the "Third Line Construction" to strengthen national defence. In the nationwide "great third line" construction, the inland Third Line areas became the focus of industrial construction [31], and Tianjin, which was in the first line coastal area, lost its industrial status. In the context of the "small third line" construction, the development of industry in the city's hinterland [31], Tianjin's industrial construction also showed a pattern of decentralization.

In summary, Tianjin's industrial heritage showed a spatial and temporal trend of "clustering first, then dispersal" during the period 1860–1978. From the opening of the port of Tianjin in 1860 to the "Third Line Construction" in the 1960s, Tianjin's industrial heritage gradually clustered, showing an overall pattern of distribution along the Haihe River, the Jingfeng Railway and the Jinpu Railway. Three clusters were formed in the downtown area and at the Haihe River estuary. After the "Third Line Construction", Tianjin's industrial heritage was gradually dispersed throughout the territory of Tianjin.

3.2. Relationship between Industrial Heritage Distribution and Buffer Zones

Based on the results of the above analysis, it can be seen that the distribution of industrial heritage in Tianjin is closely linked to the important early-modern transportation lines—Haihe River, Jingfeng Railway and Jinpu Railway—and therefore, the relationship between industrial heritage sites and transportation lines was further analysed. Using the buffer zone tool of ArcGIS 10.2 software, the buffer zones of each width of the Haihe River, Jingfeng Railway and Jinpu Railway were obtained, and the intersecting and overlapping areas of each width buffer zone were fused. The number of industrial heritage sites within each width was counted using the spatial linking tool. The results are shown in Figure 5: 66 industrial heritage sites (59.5% of the total) were within 0.5 km of the main trunk, 86 industrial heritage sites (77.5% of the total) were within 1 km of the main trunk and 100 sites (90.1% of the total) were within 4 km of the main trunk. This proves that the closer Tianjin's industrial heritage is to the Haihe River, the Jingfeng Railway and the Jinpu Railway, the more dense it becomes, and the spatial layout of Tianjin's early modern and modern industrial heritage has a strong dependence on the transport routes. Based on the above analysis, the concept of an urban industrial heritage corridor called "Tianjin Industrial Heritage Route" is proposed, with the Haihe River, the Jingfeng Railway and the Jinpu Railway as the backbone of the corridor, linking the industrial heritage along the route and promoting the holistic conservation of the industrial heritage of Tianjin as a whole.



(**a**) (**b**)

Figure 5. (**a**) Map of the Tianjin Industrial Heritage Buffer Zone; (**b**) cumulative percentage of industrial heritage within buffer zones of different widths in Tianjin.

3.3. Analysis of the Spatial Distribution and Reuse Status of Industrial Heritage by Resource Type

3.3.1. Reuse and Conservation Status Statistics

As of June 2020, the Tianjin Industrial Heritage Census GIS Database contains 111 items of industrial heritage. Of these, 16 are protected and 95 are not on the Chinese government's cultural heritage protection list at all levels. Among the 16 protected heritages, there are 4 national-priority cultural relic protection sites, 10 municipal-level cultural relic protection sites and 2 historical buildings of Tianjin (Figure 6a). It can be seen that the current state of conservation of industrial heritage in Tianjin is poor. The number of protected industrial heritage sites is very small, accounting for only 14.4% of the total; moreover, among the 16 protected industrial heritage sites, most of them are mainly industrial ancillary heritage sites such as office buildings. There is less protection for industrial heritage plants. The reuse of industrial heritage is dominated by cultural and creative parks and commercial buildings, accounting for 72.4% of the total, which shows that the reuse mode of heritage is relatively homogeneous and needs to be developed (Figure 6b).

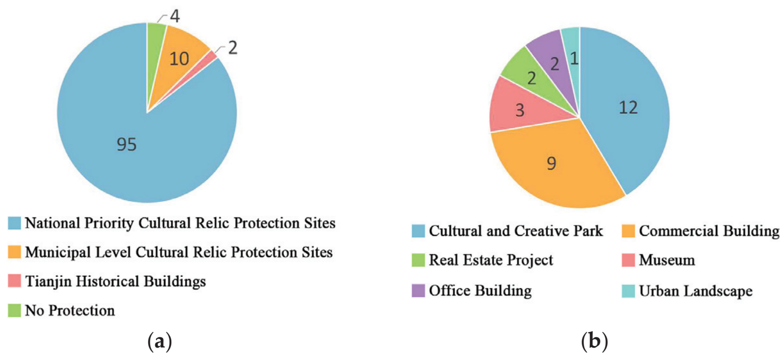


Figure 6. Current status of conservation and reuse of Tianjin's industrial heritage: (**a**) statistical map of the levels of protection of industrial heritage in Tianjin; (**b**) statistical map of the types of industrial heritage reuse in Tianjin.

In summary, the rational reuse of heritage that is not covered by the conservation system has become an important issue in Tianjin's industrial heritage.

3.3.2. Analysis of Industrial Heritage Resource Types and Their Reuse

With regard to the types of industrial heritage, previous studies have classified the types of industrial heritage in terms of the production industries and scale hierarchies and summarized the reuse patterns of different types of industrial heritage [47,48]. Based on relevant studies, the author combined the specific resource types of industrial heritage sites in Tianjin and divided them into three major categories, namely, plant type, building type and structure type, according to the differences in their material composition types (Figure 7), and typical examples of each resource type of industrial heritage are shown in Figure 8. The resource types of industrial heritage and their spatial distribution are important factors influencing the reuse of heritage [49]. Statistics on the number and reuse status of the three types of industrial heritage are shown in Figure 9. The current state of industrial heritage reuse varies greatly between the different types. The plant type and building type are relatively good, but the structure type, not yet.

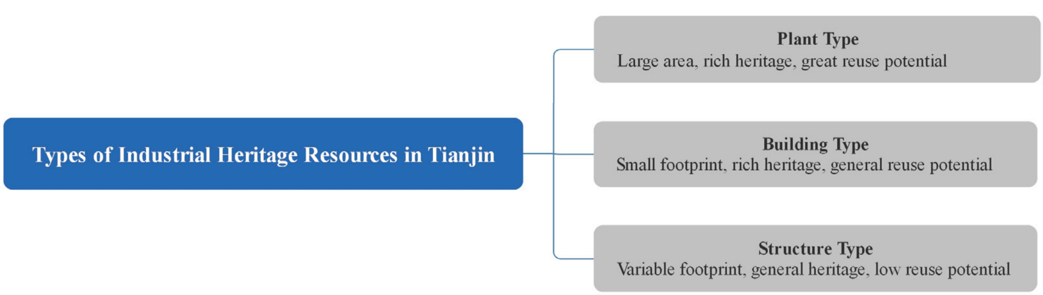


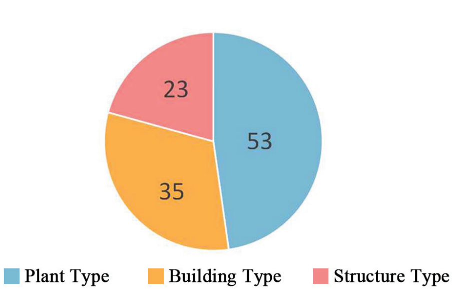
Figure 7. Resource types of industrial heritage in Tianjin and their characteristics.

(**a**)

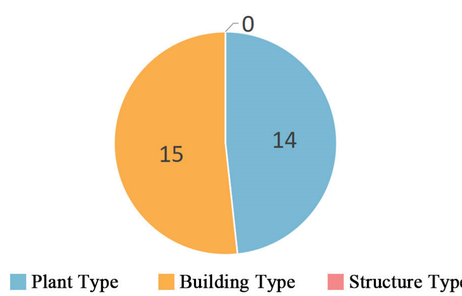
(**b**)

(**c**)

Figure 8. Typical examples of industrial heritage in Tianjin by resource type: (**a**) plant type: Baochengyu Big Yarn Factory before and after renovation; (**b**) building type: the former Jardine Matheson building; (**c**) structure type: Wanguo Bridge.



(**a**)



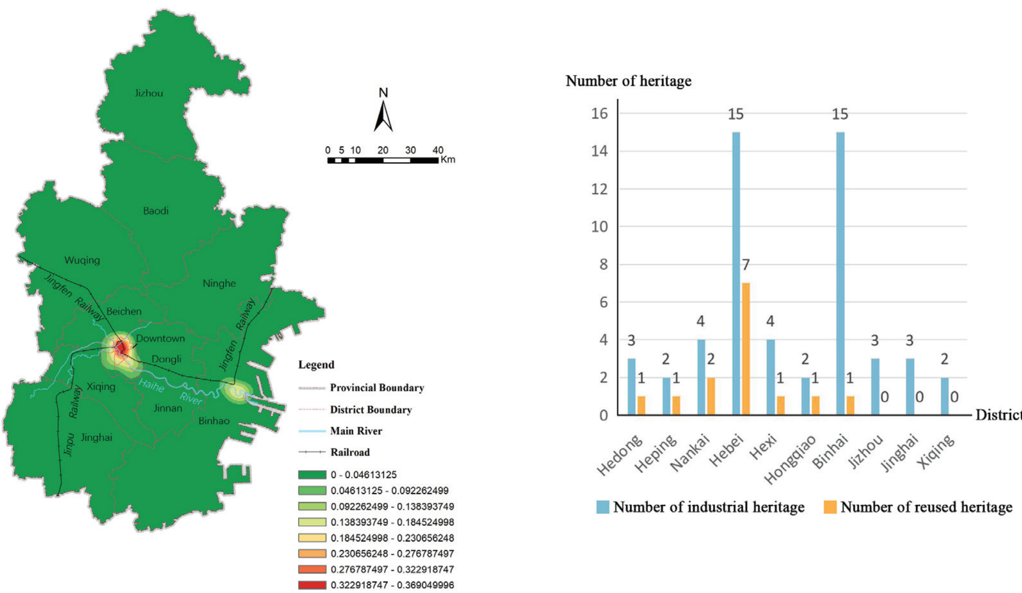
(**b**)

Figure 9. (**a**) Statistical map of the resource types of industrial heritage in Tianjin; (**b**) statistical map of the current status of reuse of industrial heritage resource types in Tianjin.

Plant Type

The plant type refers to the existence of industrial heritage in the form of an industrial factory, which generally includes the industrial heritage environment, the heritage of industrial buildings and structures and the heritage of industrial equipment. This type of industrial heritage covers a larger area, usually several hectares to several dozen hectares, or even hundreds of hectares, and contains a richer heritage. It has higher heritage value and higher reuse value and possibilities.

The results of the analysis of the distribution of the plant-type industrial heritage using GIS kernel density estimation are shown in Figure 10a. The plant-type industrial heritage in Tianjin is mainly distributed in the six districts of the downtown and the Binhai District; there are particular concentrations in the Hebei District and Binhai District at the Haihe River estuary, and there is a smaller amount in other areas. This result is closely related to the modern urban development of Tianjin. Statistics on the number of plant-type industrial heritage sites and the number of adaptive reuse sites in all districts and counties of Tianjin are shown in Figure 10b. The reused plants in Tianjin are mainly concentrated in the six districts of the downtown area, and the number of reused plants in some districts is close to half of the total plant-type industrial heritage in those districts, and the form of use is mainly cultural and creative industrial parks. Other districts and counties have very few reused factory sites, and Binhai District has the largest amount of existing plant-type industrial heritage, but only one example of a reused plant.



(**a**) (**b**)

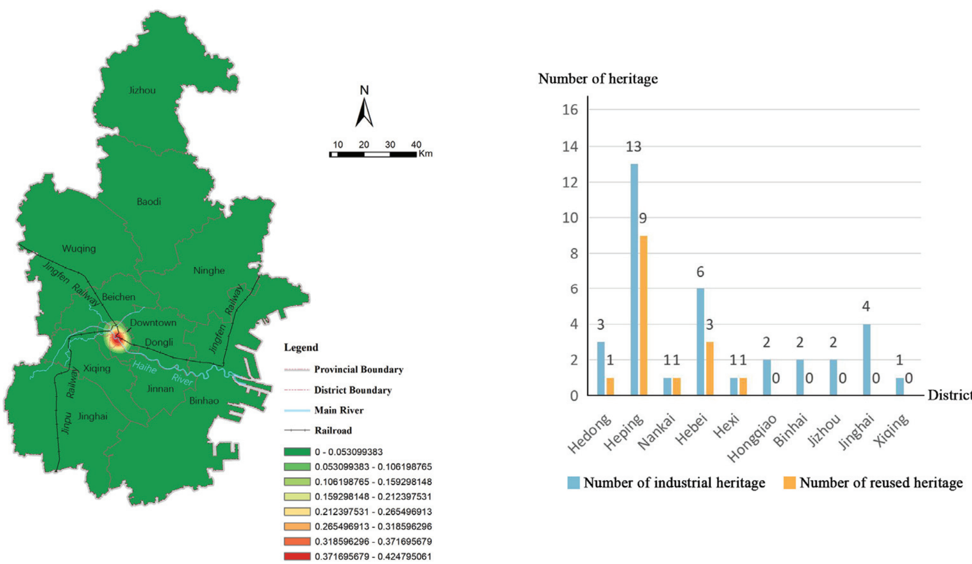
Figure 10. (**a**) Analysis of the kernel density of plant-type industrial heritage in Tianjin; (**b**) statistics on the total amount of plant-type industrial heritage sites and the amount of their reuse in Tianjin by district.

A comprehensive analysis of the distribution and reuse status of the plant-type industrial heritage shows that the areas with the greatest reuse potential are concentrated in Binhai District, followed by Hedong District, Hebei District and Nankai District; Heping District, Hexi District and Hongqiao District have less potential for reuse due to the small amount of land reserves in the factory area.

Building Type

The building type refers to the industrial heritage in the form of a building, which generally includes the heritage building and the movable cultural relics, such as industrial equipment within it. This type of industrial heritage generally covers an area of several hundred square metres to several thousand square metres and is not necessarily less valuable than the plant-type industrial heritage, but is less likely to be reused, as it occupies less physical space.

The distribution of the kernel density of building-type industrial heritage in Tianjin is shown in Figure 11a, which shows that this type of industrial heritage is mainly concentrated in the six districts of the downtown area; there is very little in other areas. Statistics on the number of building-type industrial heritage site and the number of renovation and reuse sites of the same kind in all districts of Tianjin are shown in Figure 11b. Heping and Hebei Districts have the highest total numbers of building-type industrial heritage sites and the highest number of reuse sites; the other districts have lower total numbers of heritage sites and fewer reuses.



(**a**) (**b**)

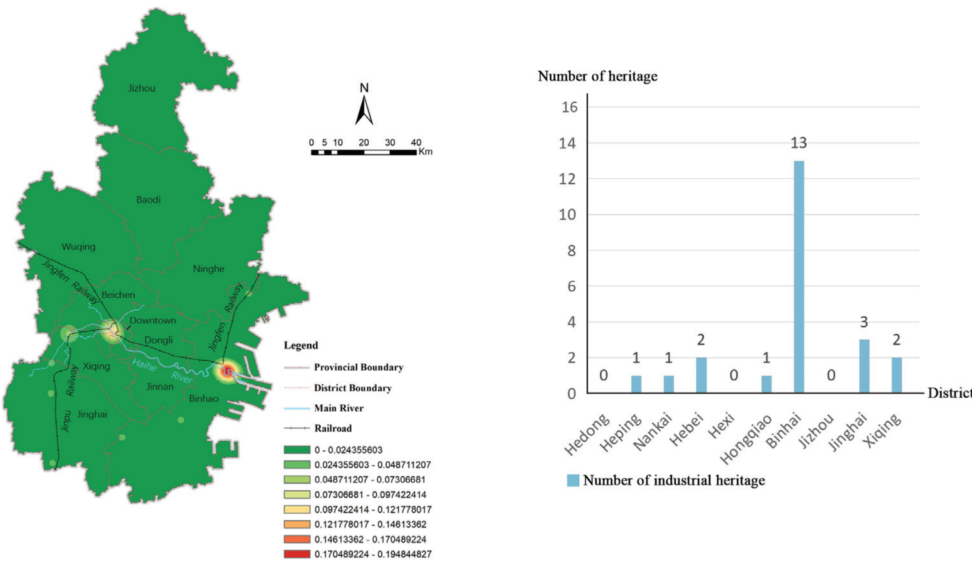
Figure 11. (**a**) Analysis of the kernel density of building-type industrial heritage in Tianjin; (**b**) statistics on the total amount of building-type industrial heritage and the amount of its reuse in Tianjin by district.

In summary, the current state of renovation of architectural industrial heritage in the Heping and Hebei districts is good, and there is still a certain amount of unimproved industrial heritage, so there is also greater potential for future adaptive reuse.

Structure Type

The structure type refers to the presence of the industrial heritage site in the form of a structure. This type of industrial heritage includes linear railways, bridges and smaller structures, such as wharves, water towers and chimneys. The former is more limited in the way they can be reused due to their overly narrow footprint and functional limitations (e.g., industrial tourist train lines), and the latter also become less likely to be reused than the plant type and building type due to their size and structure.

The kernel density distribution of structure-type industrial heritage in Tianjin is shown in Figure 12a, which shows that this type of industrial heritage is mainly concentrated in Binhai District; there is less of it in other areas. Statistics on the number of structure-type sites in each district of Tianjin are shown in Figure 12b. There are 13 items in Binhai District, accounting for 62% of the total. Moreover, there are no cases of reuse of the structure-type industrial heritage in Tianjin, and the current status of reuse is poor. Maintaining its existing function as a "living landscape" of industrial heritage along the Haihe River is a good way to keep it active.



(**a**) (**b**)

Figure 12. (**a**) Analysis of the kernel density of structure-type industrial heritage in Tianjin; (**b**) statistics on the total amount of structure-type industrial heritage in Tianjin by district.

4. Discussion

In general, there are three distinct clusters of industrial heritage in Tianjin, but there is clear heterogeneity in the spatial distribution of the sites from different periods. From 1860 to 1978, the industrial development of Tianjin was divided into two periods, with the "Third Line Construction" in the 1960s as the nodal point. Between 1860 and 1957, the construction of early modern military industries by the "westernization group", the construction of private capital industries, the planning and construction of the "nine country concession" and the industrial construction of the Hebei New District all objectively contributed to the development of early modern industry in Tianjin [28] and thus established the spatial pattern of three clusters of modern industrial heritage in Tianjin along the important transport routes. After the founding of the People's Republic of China in 1949, Tianjin experienced a short recovery period (1950–1957) and lost its status as the industrial centre of the north in the context of Soviet aid [50,51], after the start of the "Third Line Construction" in 1964, in response to the demand for decentralisation and concealment of the country's defence [52,53], Tianjin's industries began to expand outward from the three clusters. The spatial distribution of Tianjin's industries showed a change of "gathering first, then scattering". On the whole, the centre of gravity of the distribution of Tianjin's industrial heritage shifted dramatically. The overall distribution range was relatively stable between 1914 and 1957, concentrated along the Haihe River and gradually expanded after 1958.

According to the buffer-zone analysis, Tianjin's industrial heritage is clearly distributed along the main transport routes including the Haihe River, the Jinpu Railway and the Jingfeng Railway. There are 86 items of industrial heritage within 1 km of the main trunk, accounting for 77.5% of the total. Recently, the concepts of "heritage corridors" and "cultural routes" proposed by the US and Europe have become new directions in the field of cultural heritage conservation, and large-scale, cross-regional linear cultural heritage is receiving more and more attention [2,54–57]. The spatial and temporal distribution characteristics of Tianjin's industrial heritage are compatible with the concept of linear industrial heritage, and the construction of the "Tianjin Industrial Heritage Route" will provide new ideas for the overall conservation of Tianjin's industrial heritage on a regional scale.

Like other regions in China, Tianjin has only a few industrial properties located in the heritage conservation system. While more attention has been paid to Tianjin's industrial heritage in recent years, adaptive reuse of the heritage is perhaps a more practical approach than its alarming rate of loss [58]. The resource types to which industrial heritage belongs and its distribution are important conditions for its successful reuse. Based on the above analysis, the three types of industrial heritage are ranked in descending order of reuse potential: plant type, building type and structure type. In terms of their spatial distribution, the plant type and building type are mainly concentrated in the six inner districts of the downtown, which is in the leading position in terms of economic development and population in Tianjin, and therefore, has a greater potential for reuse. The structure type is mainly located in the Binhai District, and given its own resource type characteristics, this type of industrial heritage has a low use value in reuse and can be explored as a way to transform the industrial "living landscape". A holistic conservation strategy for the heritage corridor is also important for the reuse of this type of industrial heritage.

Tianjin's industrial heritage, as a witness to the city's development, should be given due protection in the context of urban development. In the operation of cities, where governments and investors prioritise urban prosperity, while heritage conservation units and research institutes prioritise the preservation of architectural monuments, finding the link between the two is a key part of heritage conservation [59]. Industrial heritage sites are an important part of the city, and their conservation cannot be separated from the urban context in which they are located but should pay more attention to their interaction with the city [60]. From 2008 to 2021, 17 cities in China have joined the UN Creative Cities Network [61], and the reuse of industrial heritage in Tianjin to support the construction of Tianjin's creative city may become the connecting point between the conservation of industrial heritage and urban development in Tianjin.

The lack of knowledge of industrial heritage by the author's team at the time led to the absence of information on industrial equipment heritage in that particular census of Tianjin's industrial heritage. The value of industrial equipment heritage as a material carrier of the history of industrial-related technological development and social development has now been widely recognized [32,62,63]. Therefore, no specific discussion was presented in this study for the time being, and the team will make up for it in future studies. In addition, this study does not provide an in-depth discussion and scientific classification of the conservation status of industrial heritage, which is a direction for future work.

5. Conclusions

Based on the census data of industrial heritage in Tianjin, in which the author participated, this study constructed the Tianjin Industrial Heritage Census GIS Database, with the years of industrial heritage spanning from 1860 to 1978. Based on the database, kernel density analysis, mean centre analysis, deviation ellipse analysis and buffer-zone analysis were used to study the spatial and temporal distribution of industrial heritage in Tianjin. From the temporal perspective, the spatial distribution of industrial heritage shows a pattern of "gathering first, then scattering". The 1960s are a nodal point for two periods, and the overall spatial distribution's centre of gravity changed drastically. From the spatial perspective, the existing industrial heritage shows a clear pattern of distribution along the Haihe River, Jingfeng Railway and Jinpu Railway; and three clusters formed in the six districts of the downtown and the Binhai District. This indicates that during the century of industrial construction in Tianjin, the industrial clusters have changed to some extent but remain in a stable geographical range overall. The evolutionary characteristics of the distribution in the temporal dimension and the current distribution characteristics in the spatial dimension of Tianjin's industrial heritage provide an important basis for the conservation of Tianjin's industrial heritage as a whole, and thus the concept of an urban industrial heritage corridor called the "Tianjin Industrial Heritage Route" is proposed.

The study also analysed the current situation of the conservation and reuse of industrial heritage in Tianjin, and focused on more promising reuse models. The resource types and their distribution are important factors for determining the reuse potential of industrial heritage. The plant-type and building-type industrial heritage concentrated in the six districts of the downtown area have greater potential for reuse and can be priority areas for later adaptive reuse. The structure-type industrial heritage concentrated in the Binhai District can be improved by defining its position in the industrial heritage route of Tianjin as a landscape along the heritage route. The above analysis will help to propose macro-strategies from the overall perspective of industrial heritage conservation in Tianjin and help the construction of a creative city. Compared to other cultural heritage, industrial heritage often occupies a more prime location and larger urban land area. In terms of urban land use planning, the results of this study can be used as a basic reference for relevant organisations to determine the nature of land use in industrial heritage sites, so that such sites can be considered as a whole and omissions can be avoided, thereby making the reuse of industrial heritage an important part of sustainable urban development.

In the context of China's urbanisation transformation, this study may also provide a new direction for the study of industrial heritage in other cities. In addition, based on the results of this study, further exploring the construction of an urban industrial heritage conservation system or delving into the analysis within industrial heritage clusters would be an important direction for future industrial heritage research.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land11122273/s1, Table S1: Tianjin Industrial Heritage Survey Form.

Author Contributions: J.Z. and H.S. conceived the whole structure, accomplished the data collation and wrote the paper. S.X. and N.A. performed the validation and revised the paper. All authors have read and agreed to the published version of the manuscript.

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Review

Progress and Prospects in Industrial Heritage Reconstruction and Reuse Research during the Past Five Years: Review and Outlook

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Abstract: The reconstruction and reuse of industrial heritage has constituted important means for the protection of that heritage, and has played a crucial role in promoting urban renewal and sustainable urban development. In this study, we reviewed 404 pieces of literature on industrial heritage reconstruction and reuse published in the past five years (January 2017 to August 2022), which includes the most representative studies (those published in key journals in the field) or the most influential studies (those highly cited). We then used three keyword tools (WordStat, Weiciyun and CiteSpace) and conducted keyword extraction, analysis and meaning presentation of 404 studies, finally identified three main research themes: (1) the current barriers to industrial heritage reconstruction and reuse, (2) the coping strategies for industrial heritage reconstruction and reuse, and (3) the evaluation of the effects of industrial heritage reconstruction and reuse. Our results revealed and clarified the latest trends in international research. Meanwhile, we also pointed out the inadequacies of the current research, such as ignoring important topics and the limitations of research methods. We hope that our research could inspire future research on industrial heritage reconstruction and reuse.

Keywords: industrial heritage; barriers to reconstruction and reuse; strategies for reconstruction and reuse; evaluation of the effects of reconstruction and reuse

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1. Introduction

1.1. Industrial Heritage Reconstruction and Reuse

Industrial heritage represents key historical material evidence that testifies to the development of human industrial civilization, industrial technology and industrial systems. It has important historical, social, scientific and aesthetic value. Since the International Committee for the Conservation of the Industrial Heritage (TICCIH) adopted the Nizhny Tagil Charter For The Industrial Heritage in 2003, the concept of industrial heritage has been clearly defined internationally; it consists of "the remains of industrial culture which are of historical, technological, social, architectural or scientific value. These remains consist of buildings and machinery, workshops, mills and factories, mines and sites for processing and refining, warehouses and stores, places where energy is generated, transmitted and used, transport and all its infrastructure, as well as places used for social activities related to industry such as housing, religious worship or education" [1].

Scholars have recognized that there are generally two ways to protect industrial heritage: specimen static protection and "development oriented" dynamic protection. The former focuses on "authenticity", while the latter injects new vitality into industrial heritage based on this authenticity. By being "reconstructed and reused", industrial heritage can fulfill current needs.

Paradoxically, there is no consensus about the concept of industrial heritage reconstruction and reuse. On the one hand, although the concept of "industrial heritage" has been clearly defined in the Nizhny Tagil Charter For The Industrial Heritage, it is inseparable from the concepts of "industrial architecture", "industrial land" and "industrial brownfield". The reason for this inconsistent presentation is that different scholars belong to different disciplines or research fields, and their research perspectives are also varied. On the other hand, most researchers have shown that reconstruction and reuse are equivalent to adaptive reuse, temporary use, etc. They have not differentiated much between the terms in their research. For example, some researchers have noted that the concept of "reconstruction and reuse" was clearly defined in the Burra Charter adopted in 1979 [2,3]. Indeed, the Burra Charter uses the term "adaptive reuse". A small number of researchers have shown a difference between the terms and proposed the concept of "reconstruction and reuse" [4]. Nevertheless, these scholars have not gone further and have not analyzed the concept deeply. This study shows that industrial heritage reconstruction and reuse has a specific meaning and application, and that it is necessary to clarify the terms to facilitate theoretical research that can serve practical projects.

As the words imply, industrial heritage reconstruction and reuse refers to the reuse of industrial heritage. It is possible to deconstruct the notion into "industrial heritage", "reconstruction" and "reuse". "Industrial heritage" is the object, and "reconstruction" and "reuse" are the means. Here, "reconstruction" is not an adjective but a noun that is juxtaposed to "reuse". Both reconstruction and reuse are reflected in practice, but reconstruction and reuse are sequential, with reconstruction happening first, followed by reuse. In examining industrial heritage reconstruction and reuse from this perspective, we found that it is different from general industrial heritage reuse such as "adaptive reuse" and "temporary use". Scholarly definitions have emphasized reuse on the basis of the preservation of original buildings, whether reuse entails "adaptive reuse" [5] or "temporary use" [6]. However, reconstruction and reuse has emphasized the means by which "reconstruction" occurs. Reestablishment, expansion, renovation, and refurbishment have been used when existing structures are not suitable for new purposes or are not safe enough to be retained [7]; these approaches can be incorporated in the concept of "reconstruction and reuse" because they conform to the concept of "reconstruction". Therefore, compared with the general concept of reuse, "reconstruction and reuse" undoubtedly has greater meaning and relies on a wider vision. According to the definition, we contend that industrial heritage reconstruction and reuse should include the general reuse strategy of injecting new life into industrial heritage by preserving original buildings [5] and making functional changes [8]. Reconstruction and reuse should also entail reuse based on the reconstruction of the layout of the new buildings and spaces to infuse continuity in the spirit of the place. This approach includes five strategies, including internal juxtaposition, renovation and implantation, structural reconstruction, external juxtaposition, and reconstruction and expansion; these strategies constitute the conceptual framework for industrial heritage reconstruction and reuse, as shown in Figure 1. The framework is also the primary starting point of this study.

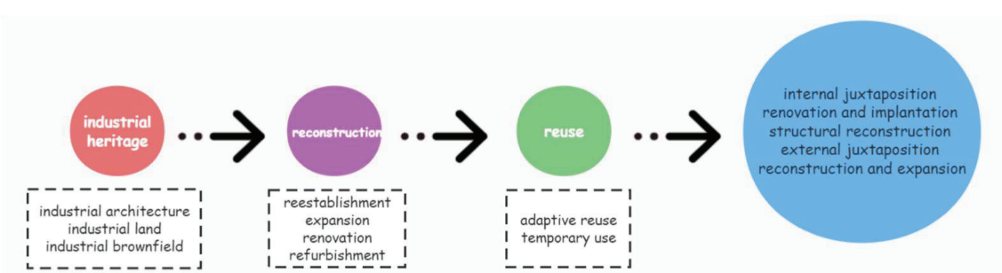

Figure 1. Schematic diagram describing the concept of industrial heritage reconstruction and reuse (by author).

1.2. Literature Review

The most recent studies have indicated the latest trends and directions in the field of industrial heritage reconstruction and reuse; in particular, research published in the past five years has been more representative and leading of the field. Therefore, in this paper, we reviewed the literature published from 1 January 2017 to 1 August 2022, and found that the authors of the reviewed literature came from Europe, North America, China, Japan, and even the Middle East. They include but are not limited to scholars, architects, government officials, and heads of associations, which shows the diversity of industrial heritage research subjects participants. Some independent literature is jointly completed by different people from different institutions, countries, and even fields, and the reviewed literature also appears in various forms. Hence, our literature review is not limited to journal articles, as it also includes books and monographs, dissertations, and conference papers, and this literature review is as accurate and complete as possible. As we assembled these different types of literature formats, we provided in this paper the state of the research on industrial heritage reconstruction and reuse.

1.2.1. Sources

Because there is no authoritative definition of industrial heritage reconstruction and reuse, the relevant research results have been scattered. To avoid omitting important documents, the scope of industrial heritage reconstruction and reuse must be appropriately expanded. First, based on common terms and concepts found in the literature related to industrial heritage and reconstruction and reuse, we created thematic keywords, which include industrial heritage, industrial architecture, industrial land, and industrial brownfield, and object keywords, which include reuse, reconstruction, renewal, and regeneration. Then, we grouped and classified these keywords to form 16 search strategies, as shown in Figure 2. Next, we used these strategies to search the literature that was published in the past five years (2017–2022) in the main retrieval channels of three types of literature: books and monographs (mainly Worldcat, Goodreads, Amazon, Z-Library, and Google Books), dissertations (mainly Worldcat and Google Scholar), and journal papers and conference papers (mainly Google Scholar, Web of Science, CNKI (China national knowledge infrastructure), and Worldcat). Eventually, 404 effective search results were obtained after preprocessing, by which duplicates and irrelevant documents were removed. We then analyzed the documents retained. According to our statistics, books and monographs account for 15.6% of our data sample, dissertations account for 17.1%, and journal papers and conference papers account for 67.3%. Moreover, the language distribution of the search results is wide, which reflects that research on industrial heritage reconstruction and reuse has been global in the past five years, as shown in Figure 3.

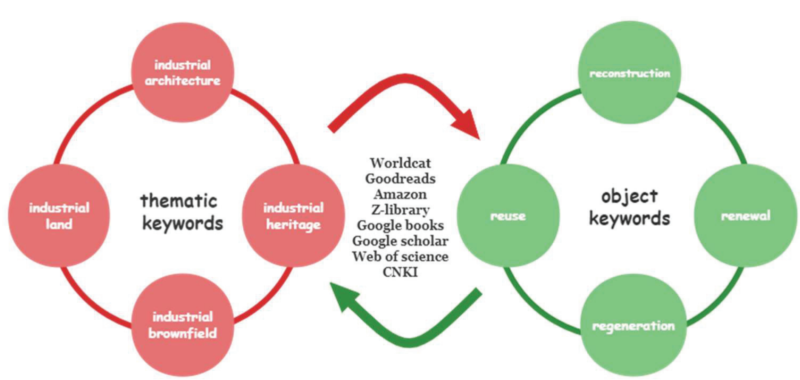

Figure 2. Research retrieval strategies (by author).

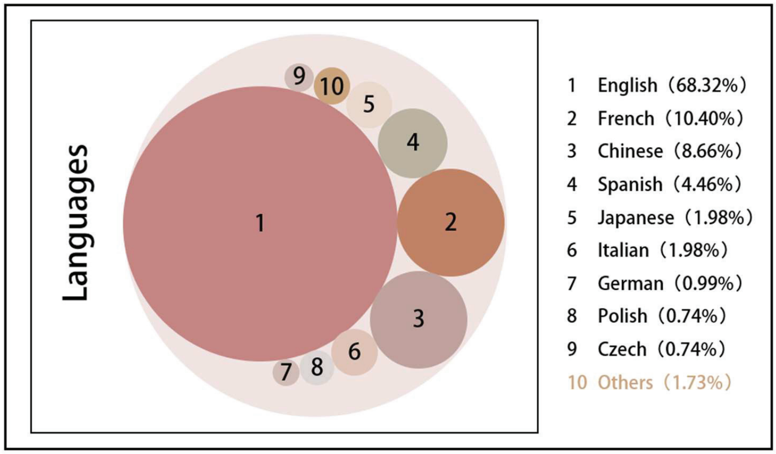

Figure 3. Language distribution of 404 literature samples (by author).

1.2.2. Description of the Literature

Out of the 404 studies reviewed, we used three keyword tools (WordStat, Weiciyun and CiteSpace) and conducted keyword extraction, text analysis and significance presentation of 404 studies, and finally identified three main research themes: (1) the current barriers to industrial heritage reconstruction and reuse, (2) the coping strategies for industrial heritage reconstruction and reuse, and (3) the evaluation of the effects of industrial heritage reconstruction and reuse. These topics have been recurrent in the research on industrial heritage reconstruction and reuse; however, other pressing issues have certainly emerged in the past five years, with corresponding innovations in research methods and perspectives. Based on our sample, we focused on new research trends to inspire future research on industrial heritage reconstruction and reuse and to fully reflect the progress this research has achieved in the past five years.

2. Current Barriers to Industrial Heritage Reconstruction and Reuse

Although industrial heritage reconstruction and reuse presents obvious benefits, "challenges and barriers involved make it futile and hard to obtain" [9]. André Fernandes, et al., highlighted the challenges and barriers of the reconstruction and reuse of waterfront areas by investigating the different foci of stakeholders, which they divided into six categories: governance (e.g., inconsistency of political vision, inadequacy of the intervention concept, inadequacy of the institutional model, inadequacy of institutional coordination, instability of the institutional model, lack of promotion and marketing); infrastructure (e.g., undefined structural projects, lack of accessibility); territory (e.g., size of the intervention areas, location of the intervention areas, metropolitan territorial model, land ownership issues); finance (e.g., lack of investment, financial liabilities, financial crisis, property market crisis); culture (e.g., industrial tradition, industrial stigma); and environment (e.g., environmental liabilities, climate change effects) [10]. These problems basically cover every aspect of the difficulties of industrial heritage reconstruction and reuse. In the past five years, research on the barriers to industrial heritage reconstruction and reuse has focused on some of these obstacles. Based on time limits imposed on the completion of any reconstruction and reuse project, these obstacles can be divided into financial and systemic barriers in the early stage of a project and into secondary problems in the latter stage of a project. Some representative literature is summarized in Table 1.

Table 1. Main literature on the current barriers to industrial heritage reconstruction and reuse.

Current Barriers		Author
Financial barriers		de Broekert, C., 2022 [9]; Yldiz, G., and Sahin Guchan, N., 2018 [11]; Dell'Ovo, M., et al., 2020 [12]; Merciu, C., et al., 2017 [13]; Nowogońska, B., 2020 [14]; Han, H., 2021 [15]; Kramářová, Z., 2018 [16]; Marian-Potra, A. C., et al., 2020 [17];
Incomplete legal system		Merciu, C., et al., 2017 [13]; Fanlei, M., and Chaojie, Q., 2020 [18]; Sadowy, K., and Lisiecki, A., 2019 [19]; Sroka, B., 2019 [20]; Wen, W., et al., 2021 [21]; Xiangguan, G., and Jiang, C., 2017 [22]; Palomares Figueres, M. T., et al., 2018 [23]; Vecchio, M., and Arku, G., 2020 [24]; Gyurkovich, M., and Gyurkovich, J., 2021 [25];
Secondary problem	Hollowing out and nihilization	Preite, M., 2020 [26]; Yong, D., 2019 [27]; Xiaojun, F., 2017 [28];
	Densification	Merciu, C., et al., 2017 [13]; Adams, C., 2021 [29];
	Gentrification	Squires, G., and Hutchison, N., 2021 [30]; Wincott, A., et al., 2020 [31]; Tideman, S., 2021 [32]; Mathews, V., 2019 [33]; Goyer, R., 2021 [34]; Radziszewska-Zielina, E., et al., 2022 [35];

2.1. Financial Barriers

Most researchers have shown that the lack of sufficient funds is the most important barrier to industrial heritage reconstruction and reuse, and that industrial heritage reconstruction and reuse projects need to find appropriate and feasible implementation methods and financial instruments [9]. In practice, "few of them are restored under poor conditions as a result of financial profits" [11]. The private sector has also often been uninterested in these projects due to "the significant remediation costs and the limited market values" [12]. Meanwhile, "the support of public actors is limited" [13], which has further aggravated the problem of funding in industrial heritage reconstruction and reuse projects.

It has happened that some private investors realized that industrial heritage reconstruction and reuse was profitable and thus invested in it, hence solving the financial obstacle encountered in the process of reconstruction and reuse. However, the short-sighted economic vision of private investors has generally pushed industrial heritage into the abyss, and the conflict of interest between the protection of heritage value and the realization of economic profits has been prevalent [14]. As Cristina Merciu, et al., pointed out, "some of the existing buildings of industrial heritage (special architecture, machinery and working tools of an outstanding value) entered a process with actions based on interests of economic gain. Interventions of brutal functional conversion affected a part of the industrial heritage, with buildings being partially or totally demolished or even being torched". This comment emerged in the context of the privatization process initiated in Romania in the 1990s, which led to the "capitalization of industrial heritage". When industrial buildings are bought by investors who often have different development aims, there is a "natural barrier" against the intervention of protective measures [13]. Due to the different degrees of capital intervention, a discourse based on power emerged, and industrial heritage became dependent on capitalist profit-seeking. The original purpose of industrial heritage reconstruction and reuse has tended to deteriorate, and protection has ceased to be a prerequisite for intervention.

2.2. Incomplete Legal System

The capitalization of Romania's industrial heritage has damaged its heritage value through the reuse process, which has also highlighted the existing problems of this heritage's protection and management system. Merciu, et al., stated that "the indifference of public administration and the bureaucratic burden related to obtaining the required approvals for the functional changes imposed by conversions and the documentation for the classification of industrial buildings as historical monuments" has had a negative impact on a process of industrial heritage reconstruction and reuse that has aimed at promoting urban renewal; hence, when planning economic policies for local, regional and national development, the protection of industrial heritage should be one of the policy objectives [13]. In fact, not only in Romania but also globally, industrial heritage protection and management have emerged as new concepts, presenting deficiencies in relatively all aspects, especially in industrial heritage reconstruction and reuse, which has become a consensual issue. Therefore, many researchers have emphasized relevant systems of industrial heritage reconstruction and reuse. Meng Fanlei and Qi Chaojie showed that industrial heritage reconstruction and reuse is inseparable from urban development and that targeted policies need to be provided at the urban level to avoid imitation and the sameness of reuse models among cities [18]. Katarzyna Sadowy and Adam Lisiecki also stressed the need for new municipal policies to better respond to grass-roots activities and socioeconomic potential in the regions at stake when studying the reconstruction and reuse of the Warsaw industrial zone [19]. Bartlomiej Sroka showed that in the revival of industrial brownfields, in spite of permanent vertical and horizontal agreements among entrepreneurs, the lack of sectoral policies may lead to the disintegration of the local economic structure [20]. The legal system has been important for industrial heritage reconstruction and reuse. No matter who the actors involved in the implementation of an industrial heritage project are, what the protection level is, and what kind of planning system and institutional environment that project is placed in [21], the legal system is essential. Moreover, researchers have not theorized on this topic enough. Therefore, Gao Xiangguan and Chang Jiang noted that research on laws, regulations, and policies needs to be strengthened in the future to provide a scientific basis for decision-making and a mechanism for the management of industrial heritage reconstruction and reuse [22].

Moreover, financial and system barriers do not only affect the early phases of reconstruction and reuse, but also influence the removal or retention of projects after reuse. For example, María Teresa Palomares Figueres, et al., showed that a reconstruction and reuse project similar to that in the La Sang community (a project that won the Spanish Fostering Arts and Design Awards in 1999) has improved the quality of life of residents. Nevertheless, “a mix of political and economical issues truncated or set aside important ongoing projects” [23]. In this regard, finance and systems have always been important factors affecting the life cycle of industrial heritage reconstruction and reuse projects.

2.3. Secondary Problems

Industrial heritage reconstruction and reuse has not always produced economic, social, environmental, cultural and other benefits. In the case of the increasingly widespread reconstruction and reuse of industrial heritage, a paradox has become increasingly prominent about the benefits of such projects. Researchers have focused on this phenomenon and put forward three warnings. First, we should be alert to the problem of “hollowing out” and “nihilization” of heritage. In the process of industrial heritage reconstruction and reuse, removing machines and their components [26] or failing to reflect the history and value of plants (including buildings) [27] will affect the value and authenticity of industrial heritage. As a result, reconstruction and reuse projects have a “shell” but no “core”, which is not only contrary to the original intention of industrial heritage reconstruction and reuse that aims to protect industrial heritage but also causes the project to face the risk of quickly becoming outdated [28].

Second, we should be alert to the consequences of “densification” in the context of the demographic explosion. Merciu, et al., showed that although industrial heritage reconstruction and reuse can produce significant economic and social benefits, “urban regeneration may result in some negative environmental impacts as well, in relation to the quality of the urban fabric and the natural environment, due to the anthropogenic pressure generated by increased attractiveness of urban space after renovation of the industrial heritage” [13]. Carmen Adams also showed that “the paradox of rehabilitation actions is also highlighted, such as the case of Cabo de Gata, where reuse can lead to environmental deterioration, despite the patrimonial recovery that in principle it entails”. In this regard, this study emphasized that people involved in industrial heritage reconstruction and reuse should consider the tolerance threshold and the load capacity of the surrounding space, as well as the intended visual improvement of the architectural complex [29].

Third, we should be aware of the negative effects of “gentrification”. Gentrification is a phenomenon that has been abundantly debated. From an economic perspective, gentrification represents the positive external effects brought by industrial heritage reconstruction and reuse [13], which promotes regional “fashionable” and “high-quality” development. However, from a social perspective, gentrification causes “undesirable” residents to be expelled from their original residences and living spaces. Graham Squires and Norman Hutchison revealed this phenomenon by showing that the new housing, whose price exceeds the economic capacity of most community members, excludes people from less privileged social classes [30]. Abigail Wincott, et al., advanced similar views. They showed that the concept of “community” is simplified due to the intervention of more influential and powerful social classes in the process of industrial heritage reconstruction and reuse. The “disturbing” cultural history and its related intangible heritage are marginalized due to its “dark” nature, and new and more benign stories are remembered and promoted. This obliteration of local culture leads to a situation in which “while landowners and developers reap the financial benefits of this transformational process, it has been widely observed that this is often—usually—at the expense of the local communities that are marginalised or displaced” [31]. This marginalization is not conducive to shaping regional identity [32]. Vanessa Mathews analyzed and studied the gentrification of the Regina warehouse area in Saskatchewan by interviewing aborigines, representatives of local businesses and key stakeholders [33]; Renaud Goyer focused on the “gentrification” of the industrial heritage reconstruction and reuse project in Trois-Rivières, Québec [34]. Scholars have focused more on the negative effects of gentrification than its positive effects.

3. Coping Strategies for Industrial Heritage Reconstruction and Reuse

The emergence of successful industrial heritage reconstruction and reuse projects has always been based on some basic principles. Therefore, among studies on industrial heritage reconstruction and reuse of the past five years, many have focused on case studies to unveil people’s experience and promote future industrial heritage reconstruction and reuse projects. Specifically, these studies have highlighted the strategies used in these projects by focusing on three aspects. The main relevant studies are summarized in Table 2.

3.1. Multisubject Participation

In the process of industrial heritage reconstruction and reuse, a wide range of stakeholders are involved, and they have different interests and positions that affect decision-making on specific projects [79] and directly impact that process [57]. Therefore, some researchers have focused on multisubject participation in the early days of research on industrial heritage reconstruction and reuse. In the past five years, an increasing number of researchers have valued multisubject participation, and the scope of their research has gradually expanded to include aspects that had been ignored by early researchers, such as old factory workers and experts. At the same time, compared with the early research on this topic, research conducted over the past five years has refined and deepened it, achieving compelling results. This research has covered four actors: the public sector, private institutions, the public, and experts. Based on different cases and perspectives, different researchers have discussed the importance and responsibilities of relevant actors in industrial heritage reconstruction and reuse.

Table 2. Main literature on the coping strategies for industrial heritage reconstruction and reuse.

Coping Strategies		Author
Multisubject participation	Public sector	Merciu, C., et al., 2017 [13]; Han, H., 2021 [15]; Sadowy, K., and Lisiecki, A., 2019 [19]; Vecchio, M., and Arku, G., 2020 [24]; Fageir, M., et al., 2021 [36]; Subin, X., and Fei, P., 2017 [37]; Bäing, A. S., and Wong, C., 2018 [38]; Subin, X., 2021 [39]; Haiyong, S., 2019 [40]; Trifa, R. M., 2018 [41];
	Private institutions	Fageir, M., et al., 2021 [36]; Rojas, L., 2020 [42]; Bosák, V., et al., 2018 [43];
	Public	Trifa, R. M., 2018 [41]; Shuting, S., et al., 2022 [44]; Wicke, C., et al., 2018 [45]; Mastalerz, A., 2019 [46]; Abuzayed, A. E., and Al-Kurdi, N., 2019 [47]; Lehigh, G. R., et al., 2020 [48]; Ifko, S., 2018 [49]; Yan, Z., 2017 [50]; Ingaramo, R., et al., 2022 [51]; Gilbertová, M., 2017 [52]; Ionica, A., et al., 2020 [53];
	Experts	Hettema, J., and Egberts, L., 2020 [54]; Pânzaru, M. D. R., et al., 2020 [55]; Oevermann, H., and Mieg, H. A., 2017 [56];
Focusing on the integrity of industrial heritage	Tangible heritage	Subin, X., 2021 [39]; Ingaramo, R., et al., 2022 [51]; Yoko, O., 2021 [57]; Jiandong, Z., 2020 [58]; Subin, X, et al., 2022 [59]; Psarri, O., 2022 [60]; Tsilika, E., and Vardopoulos, I., 2022 [61];
	Intangible heritage	Subin, X., and Fei, P., 2017 [37]; Rojas, L., 2020 [42]; Psarri, O., 2022 [60]; Zhike, A., 2019 [62]; Xuejiao, L., and Jiasheng, G., 2021 [63]; Konior, A., and Pokojska, W., 2020 [64]; Nikolić, M., et al., 2020 [65]; Zhengdong, L., 2022 [66]; Beeston, E., 2020 [67]; Bottero, M., et al., 2019 [68]; Kapp, P. H., 2019 [69];
Selecting the best reuse method	Infrastructure	Fanlei, M., and Chaojie, Q., 2020 [18]; Gyurkovich, M., and Gyurkovich, J., 2021 [25]; Radziszewska-Zielina, E., et al., 2022 [35]; Konior, A., and Pokojska, W., 2020 [64]; Subin, X., and Nobuo, A., 2019 [70]; Darchen, S., and Poitras, C., 2020 [71]; Glumac, B., and Islam, N., 2020 [72]; Hoekstra, M. S., 2020 [73]; Gyurkovich, M., et al., 2021 [74];
	Theoretical guidance framework	Bottero, M., et al., 2019 [68]; Claver, J., et al., 2018 [75]; Vizzarri, C., et al., 2021 [76]; De Gregorio, S., et al., 2020 [77]; Giuliani, F., et al., 2018 [78];

First, regarding the public sector, Mohamed Fageir, et al., showed that "it is important to uphold the role of the public sector" [36] in the process of industrial heritage reconstruction and reuse, because it controls the development of industrial heritage reuse [37] and has been shown to contribute important financial and policy support. On the one hand, the public sector is not only a major financial supporter but can also attract private investment because it is credible. Andreas Schulze Bäing and Cecilia Wong showed that the central government and the European Community were the main driving forces behind the reuse of the Media City UK project, which subsequently attracted private investment [38]. Han Han also stressed that the public sector could raise the funds necessary for the reuse of industrial heritage in the form of government guarantees through the issuance of special bonds for cultural industries and other channels [15]. On the other hand, the public sector can provide support for policies. While playing an incentivizing and driving role, the public sector can also mitigate the increase in costs and risks usually associated with such reuse activities [24]. For example, institutions of the public sector can support these activities by charging lower fees on applications for changes in land use and distributing the future income according to the stipulations specified in the contracts, turning undeveloped land into developed land and attracting investment more easily [39]. In addition, social forces can be included in such projects through policies, and the public can increasingly supervise the operation and implementation of the projects, which can reduce the occurrence of mistakes in the decision-making of the public sector [40].

Generally, private institutions contrast conceptually with the public sector and include companies, associations, and even individuals that have some capacity (including legal persons). Luc Rojas showed that factories have been widely reused by these actors since the early 1980s in France, which have been present in 63% of such projects [42]. Hence, private institutions have played an increasingly important role in industrial heritage reconstruction and reuse due to their flexibility and financial resources. Some researchers have even contended that the future of reuse "will be predominantly led by the private sector" [36]. Even so, researchers have also supported the view that the public sector needs to play a leading role in reconstruction and reuse projects [36,43].

The public refers to a group of people who have been connected with the Industrial heritage at stake in the past or directly affected by reconstruction and reuse projects; these people mainly include residents (communities) and prior factory workers. Much contemporary research has focused on the reconstruction and reuse of industrial heritage by focusing on the industrial heritage itself and ignoring the living conditions of industrial heritage communities that have been closely related to the reuse of industrial heritage [44]. Meanwhile, in many heritage sites, nonspatial forms of identity, which are based on class, religion, ethnicity, race, gender and culture, have been interlinked with spatial forms of identity [45]. The public is key in industrial heritage reconstruction and reuse. Therefore, in the past five years, many researchers have focused on this topic and emphasized the importance of incorporating the opinions of residents (communities) and prior factory workers into the different facets of industrial heritage reconstruction and reuse projects through case studies and survey interviews. Indeed, scholars have held that "local community wellbeing is one of the key factors in these renewal schemes" [46]; or, the participation of local communities in the decision-making process can ensure the success of entire operations [41,47,48]; or, heritage is "enabled by people, their work, and engagement" [49] and it is important to conduct research on people and record oral histories [50] to protect this heritage. In addition, a few researchers have focused on the relationship between the public and other entities. For example, Roberta Ingaramo, et al., showed that a solid participation by the community is a prerequisite for the reconstruction and reuse of former productive industrial buildings. Enhancing the public interest in these regions and attracting investors has been an important principle and strategy used to promote reconstruction and reuse [51]. Marie Gilbertová showed that "some of the projects that sparked the public's interest in the city's industrial history which, in turn, prompted city officials to take action to safeguard it" [52].

Experts include researchers, architects, planners and designers; they are important because they control the cultural, economic, social and aesthetic effects of industrial heritage reconstruction and reuse projects. Therefore, many researchers have asserted that "heritage professionals proved to have a great say, in the early stages of the adaptation process, in which the adaptive reuse approach was chosen" [54] and that "experts are key stakeholders that initiate and support the implementation of the regeneration projects" [55]. At the same time, because industrial heritage reconstruction and reuse is complex and requires professionalism, more stringent requirements have been proposed for the work of experts in practice. Therefore, some researchers have shown that not only do experts need a solid professional knowledge, but that professional cooperation is also needed [56].

3.2. Focusing on the Integrity of Industrial Heritage

The principle of industrial heritage integrity and research on industrial heritage go hand in hand. As early as 1998, Marilyn Palmer and Peter Neaverson wrote in Industrial Archaeology: Principles and Practice that integrity has become a key criterion in industrial heritage. In the research on industrial heritage reconstruction and reuse of the past five years, most researchers have mainly emphasized two aspects, one of which is the integrity of tangible industrial heritage, which mainly refers to the integrity of buildings and the preservation of machinery and equipment. In most of this research, integrity does not need to be intact but needs to be combined with a specific analysis of heritage value characteristics, preservation status, utilization conditions, etc. For example, Zheng Jiandong focused on cultural relics in industrial heritage and showed that the reuse of such buildings should be carried out without affecting the historical and cultural value of the building, the overall layout, and the main structure [58]. At the same time, integrity has not been limited to single buildings or single industrial heritage sites, as it has also pertained to industrial heritage areas and communities in the surrounding environment. Oyabu Yoko showed that if industrial factors other than machinery, sound and buildings are considered in reconstruction and reuse, the charm of these heritage sites would be highlighted [57]. Zhang Song further showed that, aside from the systematic protection of the integrity of industrial buildings, sites and machinery, it is also necessary to rescue and protect the living heritage related to industrial production, such as workers' new villages, factories' front areas, and supporting service sites and facilities [59]. In addition, Wang Lin also asserted that industrial heritage reconstruction and reuse projects should also consider the style and features of industrial neighborhoods [59]. The living heritage and the neighborhoods together constitute the living environment of industrial heritage, which reflects the characteristics of this heritage and conveys culture [39].

"Keeping and reusing as much of the existing buildings and facilities as possible" [51], has been recognized by an increasing number of researchers as one of the strategies to promote the reconstruction and reuse of industrial heritage.

Scholars engaged in this strategy have emphasized the integrity of intangible industrial heritage, mainly by discussing the significance of heritage and the integrity of historical narratives. The issue of the integrity of intangible industrial heritage has received unprecedented attention in the past five years. Generally, intangible industrial heritage refers to industrial historical archives, technological processes, industrial literature and art related to past industrial production process [80]; this type of heritage constitutes industrial heritage, as the tangible industrial heritage does. Globally, there has been a general tendency to value historical buildings and despise industrial production processes, machinery and equipment in the protection of industrial heritage; this attitude has led to the intangible industrial heritage being neglected in the process of industrial heritage reconstruction and reuse. Some scholars have even held the limited view that reconstruction and reuse can only occur in the case of buildings and structures and that there is no connection with intangible industrial heritage. In fact, the intangible part of industrial heritage also has reuse value [37].

Many researchers have corrected this misunderstanding. Ai Zhike showed that the protection of industrial heritage through reconstruction and reuse cannot limit itself to the planning and design of tangible heritage and that the industrial memory of both tangible and intangible heritage should be fully reflected [62]. Liu Xuejiao, et al., considered intangible industrial heritage when defining the concept of industrial heritage reconstruction and reuse and showed that the concept constitutes a resource in the process of renewing original industrial resources such as buildings, structures, land and intangible heritage that are no longer adapted to the current urban construction [63]. Therefore, intangible industrial heritage cannot be ignored in reconstruction and reuse because the degradation of cities caused by deindustrialization not only occurs "in the spatial sense (many empty postindustrial spaces), but also in the social and the economic sense (unemployment, crime, problems with the adaptation to the new, capitalistic reality)". Hence, the use of heritage for revitalization relates "not only to material aspects (tangible heritage/spatial revitalization) but also to immaterial (intangible heritage/social revitalization)" [64]. In studying revitalization, some researchers have shown that the elements of intangible heritage can be embodied "through various workshops, artistic and educational events which would revive old crafts, customs and the like, and bring them closer to the citizens—the future users of this space" [65].

Intangible industrial heritage not only constructs the environment and highlights the significance of tangible industrial heritage but also makes the latter become more valuable in itself. Therefore, this heritage should be considered in the reconstruction and reuse process. Florence Hachez-Leroy mentioned that the successful integration of dimensions other than architecture, such as economic and social history and technological history, can be meaningful [42].

In addition, when studying the practice of reconstruction and reuse, most researchers have also focused on the fact that industrial heritage has been approached from one perspective and an improper historical narration. Professor Stefan Berger, a famous European social historian and industrial heritage expert, argued that the stories of industrialization in many countries and regions in the southern hemisphere are often linked with colonialism, imperialism, and forms of violence, which may lead to the history of industrialization being forgotten, excluded or suppressed [66]. This exclusion has been the result of improper historical narratives involving intangible industrial heritage. Erin Beeston analyzed the historical narrative emanating from the Manchester Road Station of the Liverpool Manchester Railway in the process of reconstruction and reuse. This site was preserved and transformed into a science and industry museum in the early 1980s. It has made great contributions to the preservation of local and national collective memory and has been known as "the oldest extant passenger railway station in the world". Therefore, the museum has neglected other significant stories pertaining to this space of industrial heritage, such as its long history of freight transport; in fact, freight went through the station for a longer time than passengers did, but the museum has focused on passengers. In this regard, Beeston stated that "how commemoration embedded at industrial heritage sites can limit our understanding of their past" and that when a museum correctly unfolds a complete narrative about a site, it promotes the role that local narratives can play in the process of industrial heritage protection [67].

3.3. Selecting the Best Reuse Method

At present, industrial heritage reconstruction and reuse can fulfill multiple cultural purposes. Museums, exhibition centers, art studios, cultural and creative industries, commercial spaces, etc., have become the most popular ways to practically engage in reuse. In China, the proportion of reconstruction and reuse projects using these avenues is as high as 80.57% [70]. In recent years, with the increasingly close relationship between industrial heritage reconstruction and reuse and urban development, "it is necessary to think about what will best meet the needs of the local community in the long term" [64]. Therefore, an increasing number of researchers have stated that the transformation of industrial heritage into infrastructure should receive more attention and that residential projects are representative of this effort. Many researchers have emphasized the role of residential projects in the revitalization of industrial zones [25,35,71,72]. On the one hand, "profit and the desire to purchase land in a suitable location at a low price was the most significantly motivating factor that affected the decision to engage in a project in a post-industrial area" [35]. The relatively low purchase price of abandoned industrial land has been attractive to real estate agents, which makes it easier to ensure the implementation of reconstruction and reuse projects. On the other hand, the relatively low rental price has made it easier for the affordable housing provided by residential projects to be favored by the market. Brano Glumac and Nizamul Islam surveyed 220 respondents of different ages and familial background and found that "nearly 70% of respondents favored renting a unit in an adapted building" [72].

Infrastructure reconstruction and reuse projects such as residential projects are more inclusive because they are oriented to solving social problems, thus maximizing the balance between supply and demand, gathering popularity and controlling the gentrification of industrial heritage spaces [40]. Compared with the urban regeneration strategy along which local governments use cultural brands and landmark buildings to build cities into tourist destinations and places that attract capital investment, the latter can easily fall into the trap of elite projects [73] or into situations in which no one cares because these projects are out of touch with the local sense of place and the daily reality of residents who experienced the "industrial destruction"; hence, the comprehensive benefits of these projects hardly exceed those of infrastructure projects. In this regard, transforming industrial heritage into infrastructure is an effective method both in theory and practice. It is also necessary to be alert to the problem that industrial heritage reconstruction and reuse will become “real estate” due to excessive reuse in practice [18].

Because industrial heritage reconstruction and reuse constitute complex projects and measures need to be adapted to local conditions to ensure compatibility between reuse methods and industrial heritage status [13], providing a complete set of guiding methods for industrial heritage reconstruction and reuse has become a pressing issue to minimize the uncertainty of the process.

Juan Claver, et al., proposed a method for the development and evaluation of heritage value and to unveil the most compatible use by using the analytic hierarchy process (AHP) [75]. In this process, it is necessary to first determine what is the most important heritage when different heritage items of the same type need to be protected; indeed, it is almost impossible to preserve all heritage. Then, it is necessary to select the most appropriate new use for the heritage at stake according to the results of the evaluation. Corrado Vizzarri, et al., proposed an overall method of evaluation based on appropriate indicators and calibration through the AHP model and combining qualitative and quantitative methods. They analyzed and verified the former site of the Enel Power Plant in Bari, Italy, to enhance the feasibility of the method [76]. Different from Claver, et al., Vizzarri, et al., emphasized the effects of reconstruction and reuse projects in terms of meeting the needs of the population and respecting the landscape, and they chose reconstruction and reuse strategies according to these needs being met. Claver, et al., focused on the evaluation of heritage values. Although these scholars applied AHP, the former’s methodological framework covered the overall process, from choosing the subject of reuse to showing how to reuse it, while the latter focused on one aspect of the overall process and analyzed how to choose appropriate reconstruction and reuse strategies based on that process. Hence, the latter is obviously a step ahead of the former in terms of research depth.

In addition, Marta Bottero, et al., also stated that the optimal reconstruction and reuse strategy could be determined by ranking the preferences of different stakeholders for the reconstruction and reuse strategy of industrial heritage; therefore, they propose a multistandard decision support method [68]. Stefania De Gregorio, et al., were more specific and microcosmic in their study. They propose that reconstruction and reuse should first use the context analysis method to analyze the environment, including the contemporary and historical environment. Then, the architectural analysis method is chosen to analyze the buildings, determine the advantages to be used, and determine the key points to be solved. Finally, the compatibility matrix is used to optimize the data, and the reconstruction and reuse strategy that is consistent with the industrial heritage environment and buildings is selected [77]. These research results have provided certain theoretical guidance for the selection of industrial heritage reconstruction and reuse strategies and for practice.

4. Evaluation of the Effects of Industrial Heritage Reconstruction and Reuse

The evaluation of the effects of industrial heritage reconstruction and reuse not only helps to correct the deficiencies of such projects themselves but also provide a practical reference for future industrial heritage reconstruction and reuse efforts. The evaluation of the effects is certainly important. Therefore, research on the evaluation of the effects of industrial heritage reconstruction and reuse has shown a growing momentum in the past five years. Specifically, in terms of research methods, qualitative evaluation methods have been optimized, and quantitative evaluation methods have been gradually valued and improved. In terms of research targets, the evaluation of individuals has become more prominent than the evaluation of projects. Some important and representative literature on the topic is summarized in Table 3.

Table 3. Main literature on the evaluation of the effects of industrial heritage reconstruction and reuse.

Evaluation Effects		Author
Evaluation method	Qualitative evaluation	de Broekert, C., 2022 [9]; Konior, A., and Pokojska, W., 2020 [64]; Yan, Q., et al., 2019 [79]; Erlewein, S. N., 2017 [81]; Yoko, N., and Hiroshi, I., 2018 [82];
	Quantitative evaluation	Bäing, A. S., and Wong, C., 2018 [38]; Dell'Anna, F., 2022 [83]; Guiwen, L., et al., 2022 [84]; Qinna, Z., and Hang, L., 2022 [85]; Xinna, W., et al., 2021 [86]; Vardopoulos, I., 2019 [87];
Evaluation target	Individuals such as tourists and residents	Mesda, Y., and Kurt, S., 2021 [88]; Berki, M., 2017 [89]; Martinat, S., et al., 2018 [90]; Kim, E. J., and Miller, P., 2017 [91];

4.1. Qualitative Evaluation Method

Among the results of qualitative studies on the effects of industrial heritage reconstruction and reuse, the "three-pillars approach" has been the main assessment method used to assess these effects from the trifold perspective of economic, social and environmental sustainability. For example, Corné de Broekert applied the "three-pillars approach" to explore the positive impact on the economic, social and environmental sustainability of industrial heritage reconstruction and reuse projects in postindustrial cities in the Netherlands, as well as the factors affecting the degree of added value generated [9]. As research has progressed, many researchers have come to believe that the "three-pillars approach" is insufficient to meet the complex challenges faced by modern society. In addition to economic, social and environmental sustainability, cultural sustainability is also an important dimension. As Sotiria Sarri's research demonstrated, cultural sustainability is a way to maintain cultural diversity and help build inclusive societies and strengthen economies [92]. In practice, an increasing number of governmental and nongovernmental organizations have used culture as a tool for accelerating economic growth, promoting social cohesion, stability and human welfare, and solving environmental problems [93]. Therefore, some researchers have proposed the "four-pillars approach" to meet the requirements of sustainable development. The "four-pillars approach" extends the evaluation to include culture and emphasizes that the cultural dimension is "integrated on an equal basis with the other three dimensions. This approach highlights culture as (re)source and considers components of culture to include heritage, identity, memory, creativity, human knowledge and skills, cultural practices, lifestyles, value systems and diversity, among others" [81].

In addition, some researchers have focused on specific aspects of industrial heritage reconstruction and reuse projects for their evaluation. For example, Nakai Yoko and Ito Hiroshi evaluated the effects of the reconstruction and reuse of the Kiryu sawtooth roof factory from the perspective of the protection of regional characteristics and local industries; they determined evaluation criteria according to the historical and industrial characteristics of Kiryu, including whether the textile factory was located in an area facing the river, whether the three facilities (sawtooth roof factory, residence and warehouse) still existed in one place, whether the space had remained vacant, and whether textile products were still being used. Highlighting regional characteristics was at the core of their evaluation of the effects of industrial heritage reconstruction and reuse [82]. Compared with the "three (four)-pillars approach", the results of an evaluation that focuses on one aspect are undoubtedly more targeted. Nevertheless, there were also shortcomings in this study because important dimensions were omitted, resulting in the "disconnection" between the actual effects of the project and the effects that could be achieved in theory.

4.2. Quantitative Evaluation Method

To solve the problem of how to precisely quantify externalities caused by reconstruction and reuse projects, many researchers have focused on research pertaining to quantitative evaluation methods in recent years. On the basis of the "three-pillars approach", Qian Yan, et al., introduced a weighted index in relation to stakeholder demands and built a sustainability indicator system for industrial heritage reuse that includes social, economic and environmental dimensions to quantitatively evaluate the social, economic and environmental benefits of industrial heritage reconstruction and reuse projects [79]. Federico Dell'Anna estimated the economic impact of the reconstruction and reuse project implemented in the Turin's Aurora district (Northern Italy) and focused on the real estate market in the surrounding areas in recent years using an econometric model [83]. Similarly, Liu Guiwen [84], Zhao Qinna [85], Wei Xinna [86], etc., discussed the impact of industrial heritage reconstruction and reuse projects on surrounding housing prices. The research of Liu Guiwen and Zhao Qinna focused on one case or a group of cases. By using different analytical models, they concluded that reconstruction and reuse projects had a significant effect on the price of surrounding housing. Wei Xinna further explored the impact of different types of reconstruction and reuse projects on housing prices in the surrounding areas and concluded that reconstruction and reuse projects that are oriented toward commercial and cultural facilities can relatively improve housing prices in the region. In addition, Bäing and Wong used data analysis to assess the impact of the reconstruction and reuse project of Salford Quays in England on the community [38]. Ioannis Vardopoulos used the DEMATEL model to find out what elements of reconstruction and reuse projects can promote local sustainable development. He also evaluated the pattern and extent of interaction between these different factors [87]. Hence, it is predictable that quantitative evaluation methods have been prominent in this field.

4.3. Individuals as Main Evaluation Target

The results of the research conducted in the past five years on industrial heritage reconstruction and reuse have shown that individuals have become the main targets of the evaluation of the effects of these heritage projects; individual perception has become the main component of these evaluations, which is a shift from previous approaches that focused too much of projects themselves. This shift reflects changes in the concept of industrial heritage reconstruction and reuse. In the past, industrial heritage reconstruction and reuse were carried out as a way to protect heritage; nowadays, the main goal has become to promote social development and meet social needs via protection.

Based on the phenomenological method, Yasemin Mesda and Sevinc Kurt studied the spatial experience of individuals in the Nicosia Municipal Arts Centre, a museum that emerged out of the transformation of industrial architectural heritage in Cyprus. Through multisensory analysis, these scholars grasped the emotions and attitudes of individuals in that space to evaluate the effects of reconstruction and reuse [88]. Márton Berki also focused on the experience of individuals in the reused space. He focused on groups such as tourists. Through questionnaires, he studied how tourists understood and approached the venue and the ways in which they used the venue to assess the success of the reconstruction and reuse project [89]. Stanislav Martinat, et al., not only focused on tourists but also on how residents perceived a series of industrial brown land reuse projects, and they summarized people's experience in industrial heritage reconstruction and reuse projects [90]. Eujin Julia Kim and Patrick Miller also focused on residents' perception of industrial brownfields after reconstruction and reuse [91]. Hence, individuals' subjective experience has become an important starting point for most researchers to evaluate the effects of industrial heritage reconstruction and reuse projects, and tourists and residents have become important targets for researchers.

5. Conclusions

In the past five years, industrial heritage reconstruction and reuse has become a key issue in the field of international heritage protection. Research topics have been gradually refined and focused, and researchers have innovated in their research methods and perspectives, which have been integrated to varying degrees. Through the analysis of studies published in the field over the past five years, the current research on industrial heritage reconstruction and reuse still needs to be improved and strengthened; these shortcomings can serve future researchers to develop new directions in this field.

5.1. Research Perspectives

First, future research should focus on three major topics. They should establish a definition of industrial heritage reconstruction and reuse. The existing research has shown that the academic community has not yet reached a consensus on the concept of industrial heritage reconstruction and reuse. The phenomenon of "misuse" and "mixed use" has recurrently emerged, leading to scattered studies on the topics, which are difficult to bring together and systematize; hence, it has been difficult to move forward in the field of industrial heritage reconstruction and reuse. It is necessary for scholars to join forces to accelerate the integration of the concept of industrial heritage reconstruction and reuse and promote new research in the field.

Second, the COVID-19 epidemic has caused a crisis in industrial heritage reconstruction and reuse projects. The negative impact of COVID-19 on the global economy has been obvious to all. Policies aiming at reducing the size of urban agglomerations have also increased the difficulty facing reconstruction and reuse projects that rely on offline activities. As a result, it has become common for most industrial heritage sites to be forced into a state of "secondary ruins". Therefore, researchers should focus on COVID-19 as a current obstacle. Researchers should apply themselves to propose feasible strategies for solving the problems brought about by COVID-19; they should consider the pandemic when evaluating the effects of industrial heritage reconstruction and reuse projects for their studies to be more scientific and accurate. Obviously, an exploration into the relevant literature reveals that this issue has been ignored. Only a few studies have mentioned COVID-19, let alone proposed strategies to help industrial heritage reconstruction and reuse projects cope with the consequences of the epidemic.

Third, industrial heritage reconstruction and reuse has created a turnaround in rural revitalization. By analyzing and sorting out the relevant literature of the past five years, we found that most researchers have considered how industrial heritage reconstruction and reuse can promote urban regeneration and urban sustainable development and paid less attention to the role of these projects in promoting rural development. The conservation and reuse of rural heritage has become an important issue in global rural studies [94]. As a form of rural heritage, rural industrial heritage constitutes a unique cultural symbol of the countryside, it is particularly evident in Asian latecomer countries represented by China, Thailand, and Vietnam. It needs to be considered in research and promoted in practice.

On the other hand, future research should strengthen the application of two methods. First, comparative methods should be promoted. At present, most researchers have selected only a single reconstruction and reuse project as their case study, and they have even selected a single project in their verification and analysis when proposing a set of overall frameworks for the selection of industrial heritage reconstruction and reuse strategies. The problems addressed and coping strategies proposed in these studies are targeted toward specific projects, but are often not universally applicable, which affects the value of the research. The introduction of comparative analysis principles is useful to make these studies as comprehensive and thoughtful as possible, so they include all the details of a single project and enhance the persuasiveness and feasibility of the research results.

The second approach is the dynamic research method, which is particularly useful to evaluate the effects of industrial heritage reconstruction and reuse projects. Most researchers have used tourists' perceptions and experiences as references when evaluating the effects of industrial heritage reconstruction and reuse projects. However, tourists represent an unstable group, as time, weather, personality and other factors affect how many tourists there are and their experiences, which in turn affect the authoritativeness and credibility of the evaluation results. The introduction of a dynamic research method requires researchers to monitor their targets for a period of time to eliminate as best they can the contingencies caused by other factors.

5.2. Limitations

First, in this paper, we addressed the global trend in the research on industrial heritage reconstruction and reuse. The literature on this topic is voluminous and complex due to the continually increasing attention paid to industrial heritage reconstruction and reuse in recent years. The literature review here may not be comprehensive, although the important studies on the topic have certainly been included to ensure that our overall results are scientifically accurate. Moreover, due to the limitation of the length of this paper, only the most representative studies (those published in key journals in the field) or the most influential studies (those highly cited) are cited. We present the authors' perspectives rather than their papers themselves; it is thus impossible for us to list the 404 studies individually in this paper. Second, we may have been mistaken in the way we read and understood studies written in different languages, as we have been unable to master these languages. Nevertheless, we have consulted experts in the relevant languages to minimize the potential bias in the way we summarized the views of other researchers. Our research has some limitations, but we have attempted to overcome them to ensure the integrity and comprehensiveness of the summary information provided and the credibility of our research conclusions.

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Article

The Need to Articulate Historic and Cultural Dimensions of Landscapes in Sustainable Environmental Planning—A Swedish Case Study

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Abstract: Ignoring the historic and cultural dimensions of landscapes makes environmental planning unsustainable, which in the long run, will have a negative impact on both the environment and society. This paper examines the work and perceptions of practitioners with a focus on the role of historic and cultural landscape dimensions and their relation to the recent implementation of the ecosystem service framework in sustainable environmental planning. Semi-structured interviews with officials at local and regional planning levels in a Swedish case study showed that the historical landscape forms the basis for environmental work. Respondents expressed an integrated view of the landscape, and historic and cultural landscape dimensions were considered important in the initial planning process. However, several challenges existed later in the planning process and final decision-making, such as conceptual ambiguities, unclear policy and assignments, limited cross-sectorial coordination and lack of awareness, knowledge, resources and other priorities. The results also show that the respondents worked regularly with intangible landscape dimensions, which can be defined as cultural ecosystem services, but they do not label them as such. Furthermore, established knowledge and expertise of heritage planning was not activated in the implementation of the ecosystem service approach. We conclude that historic and cultural landscape dimensions are not ignored in practice, but there is a need to articulate these aspects more clearly in order to achieve sustainable environmental planning. There is also an unexplored opportunity to connect skills and create new forms of cross-sectorial collaboration between heritage planning and the ES approach.

Keywords: cultural heritage; cultural ecosystem services; historic environment; spatial planning; landscape policy; sustainable development

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1. Introduction

To achieve sustainable environmental planning, the whole environment must be considered, but previous research shows that historical and cultural perspectives on the landscape are often ignored [1–9] (The historic dimensions, "the surviving physical impacts of people on the landscape" and the cultural dimensions, "the intangible meanings, values, attributes and associations that people attach to its physical components" of landscapes [10] are integrated parts of the highly dynamic concept of heritage [11,12].

Guided by international charters and conventions, heritage conservation principles have moved from a focus on preserving historic monuments and sites towards a more integrative and people-centred focus on using the past in the present [13] and to manage change sustainably. This future-oriented approach includes not only the care for landscape materiality and characteristics but also local knowledge and history, stories and myths, crafts, minority and local identity, and collective memory [7,14–17]. The application of contemporary heritage conservation principles in local and regional planning is today a well-established practice in many parts of the world [17–21] with a vast variety of professional profiles, approaches and agendas.

With the adaptation to the principles of sustainable development [22] heritage has become more relevant in an environmental planning context. In 2005, the Council of Europe (COE) adopted the Faro Convention, emphasizing the role of heritage as a resource for sustainable development in society [23]. In 2017, the COE adopted the European Cultural Heritage Strategy for the 21st century, stressing that heritage cannot be viewed in isolation from its physical and cultural context, and that developing a high-quality living environment means considering heritage in other sectoral policies, such as development, environmental conservation and land use planning [24]. Sustainable heritage is today a developing field guided by the urgent need to address social-cultural and environmental issues together [9]. However, as argued by [25] the conservation and sustainability fields has not yet recognized nor elaborated "the full implications of considering the heritage dimension and value of nature in unison".

Integrative instruments for environmental planning are requested by both scientists and practitioners. One such instrument is the Ecosystem Service (ES) framework developed to assist environmental decision-making. ES aims to bridge natural and social sciences and facilitate collaborative management in a shared framework for assessing values in the landscape [6,26–30]. In the ES framework, the notion of landscape and its historic and cultural dimensions is central to debates on loss of biodiversity, and mostly relevant in relation to cultural ecosystem services (CES). Six categories of CES have been defined [26] including: cultural identity (the current cultural linkage between humans and their environment); heritage values ("memories" in the landscape from past cultural ties); spiritual services (sacred, religious, or other forms of spiritual inspiration derived from ecosystems); inspiration (the use of natural motives or artefacts in arts, folklore, and so on); aesthetic appreciation of natural and cultivated landscapes; and recreation and tourism. While the MA classification of ES has been developed and refined [28,30,31] heritage remains a relevant concept, as the ES approach integrates historic and cultural perspectives on landscapes and biocultural heritage into decision-making processes. However, there is a shortage of studies focusing on cultural heritage and identity and only a handful of existing ES publications gives a more comprehensive description of "newer notions of heritage" in relation to landscape [32] Another shortcoming is the focus on immaterial aspects through heritage values, which excludes the material aspects of human relations with the environment [25].

In the recent decade, due to a directive by the European Commission the EU member states have started to implement the ES approach in practice. However, the intangibility of CES, evaluation difficulties, methodological and conceptual issues as well as the fundamentally instrumental framing of the ES framework are reported to restrict the integration of CES in environmental planning and policies [6,25,32–39]. A closer collaboration and exchange of knowledge between heritage planning and the ES approach can be of mutual benefit as the methodological framework of ES, where the cultural benefits of nature are explored as resources for society, is in line with current approaches to heritage planning [16,21,32,40–42]. Taking advantage of established discourses, approaches and practices in heritage planning could possibly improve the understanding of CES beyond the current focus on recreation. Heritage planning would also benefit from such a connection as the ES approach provides a methodological framework to bridge the gap between heritage and sustainable development and to recognize cultural landscapes and natural features with cultural significance (natural heritage) in environmental planning [21,26,32,40–42].

As shown above, the historic and cultural perspectives on landscape often have little significance in sustainable environmental planning. This also applies to the implementation of ES, despite the framework having been developed with the purpose to bridge natural and social science, and facilitate collaborative management and communication across sectors. Ignoring the historic and cultural dimensions of landscapes makes environmental planning unsustainable, which in the long run will have a negative impact on both the environment and society. In theory, a closer collaboration between the fields of heritage planning and the ES can be of mutual benefit as suggested by previous studies. However, few studies have examined how practitioners understand and approach the role of historic and cultural landscape dimensions for sustainable development in environmental planning. In order to fill this gap, the aim of the present study was to examine the work and perceptions of practitioners with a focus on discussing how historic and cultural landscape dimensions are understood and articulated and what opportunities exist for intersectoral exchange of knowledge, in light of the recent implementation of the ES approach. For this purpose, we used data from a case study of sustainable environmental planning at local and regional public agencies in Sweden. The study was guided by the following research questions:

- What are the opportunities and challenges to ensure consideration of the historic and cultural dimensions of landscapes?
- Which historic and cultural landscape dimensions are considered?
- What is the awareness and knowledge about the concepts of ES and CES?
- Is the implementation of ES and understanding of CES related to the established practice of heritage planning?

2. Materials and Methods

This paper is part of an interdisciplinary research project with the aim to investigate the role of cultural heritage and the historic environment in sustainable landscape management [43,44]. The present paper draws upon data collected from interviews. A qualitative, single case study approach [45–48] was used to gain a deeper understanding of the issues at hand. The interdisciplinary project team included researchers with expertise in the field of physical geography, conservation of the built environment, psychology and biocultural heritage.

2.1. The Case Study Area

The case study area, the Lake Vänern Archipelago Biosphere Reserve, includes the municipalities of Mariestad, Götene and Lidköping with a total population of 80,000 inhabitants (Figure 1). The geographical area includes parts of Lake Vänern, the largest lake within the European Union, and an arable landscape with a varied topography consisting of post-glacial clay plains, mylonite intrusions, glacial moraine deposits and a Cambro-Silurian flat-topped mountain named Kinnekulle. People have lived in the area for at least 6000 years, and a richness in landmarks and artefacts dating back to the Bronze Age imply millennia of cultivation and influence on the landscape which is still visible in the diversity of plant species [49]. Biosphere reserves are intended as model areas for sustainable development and, in order to be designated by UNESCO's Man and the Biosphere Programme (MAB), the landscape must include both a rich cultural heritage and high levels of biodiversity [50]. The global strategy for MAB aims to guide the local regional and national implementation of Agenda 2030 by integrated planning and landscape management [51].

The Swedish Environmental Code together with the Planning and Building Act form the legal basis for environmental planning, including heritage planning, in Sweden. The aim of the Environmental Code [52] is to promote sustainable development, which will assure a healthy and sound environment for present and future generations. "The environment" is used in broad terms and includes the cultural environment. Thus, the regulatory framework makes no clear distinction between natural and cultural values of landscapes, and the Environmental Code shall be applied in such a way as to ensure that valuable natural and cultural environments are protected and preserved in combination. Furthermore, the cultural environment serves as an important aspect in sustainability policy. For example, the Swedish National Heritage Board, under the Ministry of Culture, is in charge of the 2030 Vision for cultural heritage management in Sweden. An important goal of the vision is to increase awareness that cultural heritage and the cultural environment are important parts of the work for a sustainable inclusive society [53]. Additionally, the current Swedish environmental policy includes a "generational goal," which is intended to guide environmental action at every level of society by means of 16 environmental quality objectives and a number of milestone targets. One important target, decided by the Swedish parliament, is that a majority of the municipalities, by 2025, shall integrate ecosystem services in planning, building and management of the urban built environment. To accomplish this target and the environmental policy in practice the municipalities use the detailed development plans which are legally binding and the most important instrument. The municipalities have the main responsibility for environmental planning in Sweden in dialogue with the regional planning level, i.e., the County Administrative Boards. Implementation of the ES framework has gradually increased at the regional and local planning levels in Sweden during the past 10 years, as a consequence of governmental decisions and development of national policies. Previous studies report a limited awareness of the concept of ES and a slow integration at local and regional planning levels [21,38,54] but, during recent years, the integration has increased as shown by [55]. Still, several barriers exist, such as the use of different definitions, approaches and methods as well as a lack of bridging perspectives and traditional division between nature and culture [21,38,56,57]. A recent study [55] report a "heterogeneity in the degree, focus and strategy" among the municipalities and a "gap between visions, strategic goals and their implementation" from a review of 231 Swedish municipal comprehensive plans.

Figure 1. Lake Vänern Archipelago Biosphere Reserve in Sweden includes the three municipalities, Mariestad, Götene and Lidköping. Source: Lantmäteriet state of dispersal Dnr 601-2008-855.

2.2. Interviews

In total, eighteen semi-structured interviews were conducted between 2018 and 2019 with officials employed or otherwise engaged by local and regional actors, including municipalities, the County Administrative Board, local museums, and the Biosphere Association. The respondents each had formal responsibilities related to the planning and management of historic and cultural landscape dimensions but represented a range of different occupations and disciplines, such as historians, built heritage conservation, urban and landscape planning, environment conservation, engineering, and architecture. Respondents were identified through discussions in the project group and via webpages. The respondents were approached by telephone or e-mail, and they were able to choose the location for a face-to-face interview which lasted one hour on average and was recorded and transcribed. The themes and questions analyzed in the present paper are shown in Table 1.

Each interview started with a discussion about the research project and the respondents were then asked to specify their educational and professional backgrounds, as well as current work assignments. Note that no definitions of concepts related to historic and cultural landscape dimensions were given in advance, thus the respondents' answers are based on their own interpretations. Each respondent's answers were analyzed via transcripts and audio recordings. The responses were compiled in a spreadsheet and were thematically categorized based on their semantic content. Data from the semi-structured interviews are reported using "bottom up" (based on open questions) and "top down" analyses, where "the analytic process involves a progression from description, where the data have simply been organized to show patterns in semantic content, and summarized, to interpretation, where there is an attempt to theorize the significance of the patterns and their broader meanings and implications often in relation to previous literature" [46]. These analyses were done with an emphasis on listening, meaning that the interviewer actively avoided influencing and biasing the conversation [58]. In order to thoroughly understand the data, the transcripts were read several times and when needed the original audio recordings were reviewed [46].

The questions used in the semi-structured interviews were divided into 5 themes (Table 1). In two of the themes, questions appeared both in open-ended and closed-ended formats (see Table 1). The interviewer began with the open-ended question, asking the respondents to develop and discuss their answers. Next, the respondents were asked to mark multiple choices on an A4 sheet for each question. The closed-ended part of the questions also included an opportunity for the respondents to add aspects that they thought were important. When the respondent had answered the questions, the interviewer and the respondent discussed the answers and the question. Data analysis for these two themes included data both based on the answers from the audio recording and transcripts, and from the A4 sheets. The data from the A4 sheets were transferred to an Excel sheet. Percentages of total number of respondents who considered each of the aspects presented on the A4 sheets were calculated and results plotted on a spreadsheet chart. These results were again compared and sometimes complemented with authentic citations and data from the audio recording and transcripts. For the remaining three themes only open-ended questions were used (see Table 1). Each respondent's answers were analysed via transcripts and audio recordings. The responses were compiled in an Excel sheet and were thematically categorized based on their semantic content.

Table 1. Interview instrument—themes and questions that guided the study.

Themes	Open-Ended Questions	Closed-Ended Questions
Landscape dimensions considered	Which historic and cultural landscape dimensions: Are regularly considered? Are not considered? Need more focus?	Respondents were asked to mark multiple choices related to which historic and cultural landscape dimensions they consider in their work. The respondents also had the opportunity to add choices. Red colour = regularly considered Green colour = need more focus. No mark/colour = not considered

Table 1. *Cont.*

Themes	Open-Ended Questions	Closed-Ended Questions
Status	What is the status of historic and cultural landscape dimensions in planning and management?	
Opportunities and challenges	What are your arguments and the limiting factors to ensure consideration of historic and cultural landscape dimensions in planning and decision-making?	
Ecosystem services	Are you familiar with the concept of ES and CES? Do you work with ES? How do you define CES?	
Methods and guiding policies	Which methods, directives, laws, policies, and documents guide you in your work?	Respondents were asked to mark multiple choices related to the question: "Which directives, laws, policies, and documents guide you in your work?"

3. Results

Results are presented in line with the aim and research questions presented above.

3.1. Historic and Cultural Landscape Dimensions Are Important

One strong potential identified was that historic and cultural landscape dimensions are, according to a majority of the public officials, important in the early stages of the planning process and considered on a daily basis. The results from the interviews show that the officials have a long tradition of considering man's use of nature and of using the perspective that nature and culture is both integrated and interdependent in the landscape. One example is an EU fund LIFE-nature project entitled, "Kinnekulle Plateau Mountain—restoration and conservation" which was in progress between 2002–2007 with a budget of Euro 5.7 million. Even though this project was labelled as a "nature" restoration and conservation project the historic landscape was the base for the project. In the words of one of the respondents:

> "The job was to restore and recreate old overgrown pastures and meadows and to win back the old cultural landscape. We included quite a lot of land in this project, often not based on the natural values, instead based on, for example, old boundaries, village boundaries between grazing and outfield. The project was based on a combination of cultural history and natural values".

However, results also show several challenges to ensure consideration of historic and cultural landscape dimensions in later phases of the planning and decision process. These challenges were related to conceptual ambiguities, unclear policy and assignments, limited cross-sectorial coordination, lack of awareness, knowledge, resources and other priorities as described below.

3.2. Conceptual Ambiguities

The interviews revealed that public officials talk about and define historic and cultural landscape dimensions in various ways. There are conceptual ambiguities with a wide range of definitions. Some officials talk about designated buildings and areas of national interest, i.e., the material heritage that is strongly linked to the legal framework. Others talk about historic and cultural landscape dimensions in more general terms synonymous with a changing landscape, or as one official put it:

> "A process—it changes because historic and cultural dimensions are the impact of humans on the environment, the landscape and the buildings . . . ".

Some other respondents argue that the concept is a sensitive topic that tends to be perceived as fluctuant opinions, based on attitudes, rather than professional judgments. In order to increase the influence of historic and cultural landscape dimensions in current practices they describe how they have to find innovative ways, as for example showing its instrumental value for the tourism industry.

3.3. Unclear Policy and Assignments

The conceptual ambiguities are closely related to unclear policy and assignments as reported by several respondents. A partial or complete lack of political governance documents and policy, including cultural heritage management programs, is one reason. Another reason put forward is that the politicians do not always use their own governing documents. One respondent expresses the unclear policy and assignments in the following way:

> "After all, there is a political program, where you put forward nice wishes about how things should be. The ideas are put into an action plan where you make priorities, but historic and cultural values are rarely highlighted, so we lose it on the way. You continue to work and continue to feel that you have no control. I would like to have an action plan with headings, such as cultural heritage, that include the activities we have on this topic. What is the focus of our attention? How can we work successfully? At present, some idea pops up and, yes, we implement it but our work on cultural heritage becomes event driven."

Several respondents argue that the only way to increase the status of historic and cultural landscape dimensions in environmental planning is to promote political decisions that make cultural heritage programs and other policy documents an integral part of the municipal comprehensive plans. A majority of the respondents answered that they used the National environmental quality objectives, Planning and Building Act, local cultural heritage programs and the Historic Environment Act for guidance in their work. A few respondents argued that the ideas of the European Landscape Convention (ELC) inspired them in their work although less than a third used it as a guiding document on a daily basis.

3.4. Limited Cross-Sectorial Coordination

Even though most respondents share a view of the integrated landscape where nature and culture are interdependent, the idea that aspects related to historic and cultural landscape dimensions belong in a certain department, such as the planning department, is deeply rooted. In the words of one respondent who worked with local history and stories in networks of local stakeholders, and NGOs such as local museums and collections of industrial heritage, e.g., sawmills, stone masonry, dairies, machines, etc.:

> "I don't consider myself to work with historic and cultural landscape dimensions as I don't work with physical places . . . there has been no political awareness and much of this work seems to belong to the planning office . . . much has been left to the non-profit NGOs . . . I can't say with good conscience that we have clear structures. We would, if we pushed in the same direction and knew what we wanted, be a force in the right direction. Instead, it is a force that spreads in all possible directions . . . "

Existing sectoral funding and organization at national, regional and local planning levels are one reason for the limited cross-sectorial coordination. A majority of the respondents argued that increased cooperation between local and regional agencies and other actors is required to integrate the cultural and natural landscapes values to reach a sustainable development (Eliasson et al. unpublished).

3.5. Lack of Awareness, Knowledge, Resources and Other Priorities

Respondents argued that there is a lack of awareness and knowledge among politicians, developers and the public about the role of historic and cultural landscape dimensions in environmental planning. This is primarily related to individual politicians rather than political parties. The political term of office of only four years makes the change of individual politicians an educational challenge for the public officials. In Sweden, the public's influence on the planning process is ensured through the National Planning and Building Act. Respondents describe that sometimes when they talk with, for example, house-owners about historic and cultural landscape dimensions it creates tensions. Landowners often consider the Historic Environment Act as a threat to them as they think that increasing awareness of historic and cultural values will increase costs and mean limitations on their land. Developers fear increased costs and delays. Some respondents describe difficulties in making politicians, developers and the public listen to facts. Or, in the words of one respondent:

> "Ignorance is an incredible resistance, especially when it is paired with fact resistance and denial of knowledge".

Education is a solution to the lack of awareness and knowledge according to some of the respondents who were engaged in education of politicians and the public. However, the respondents did not use public participation methods on a regular basis. Most respondents argue that the organization's finances and priorities are one important constraint leading to a limited budget for heritage planning.

3.6. Historic and Cultural Landscape Dimensions Considered

The historic and cultural landscape dimensions most often considered by the public officials on a regular basis (Table 1, closed-ended questions) are shown in Figure 2. More than sixty percent of the public officials claim they regularly (daily) work with buildings and industrial heritage. More than fifty percent of the respondents worked regularly with place identity, agricultural environments and green areas, and 45% worked with aspects of landscape views and local history on a daily basis (Figure 2). Thus, it is evident that the public officials regularly worked with both tangible and intangible heritage. The open-ended questions revealed (Table 1) a close connection between the tangible and intangible heritage as the respondents worked with aspects such as local identity, history and shared stories in relation to the industrial, agricultural and built-up heritage.

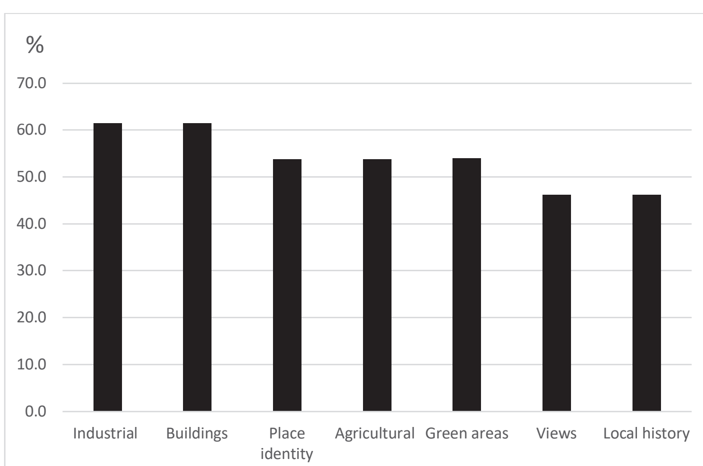

Figure 2. The x-axis shows the seven most important historic and cultural landscape dimensions that are regularly considered in the planning process (measured as percentage, y-axis). See also Table 1, closed-ended questions.

Respondents were also asked which historic and cultural landscape dimensions that need more focus (Table 1, closed-ended questions). As shown in Figure 3, more than fifty percent of the public officials wanted to focus more on local history. Other dimensions that need more focus in the planning process, according to a third of the respondents, are meeting places, the dark heritage [59], experience, agricultural environments, local knowledge and stories.

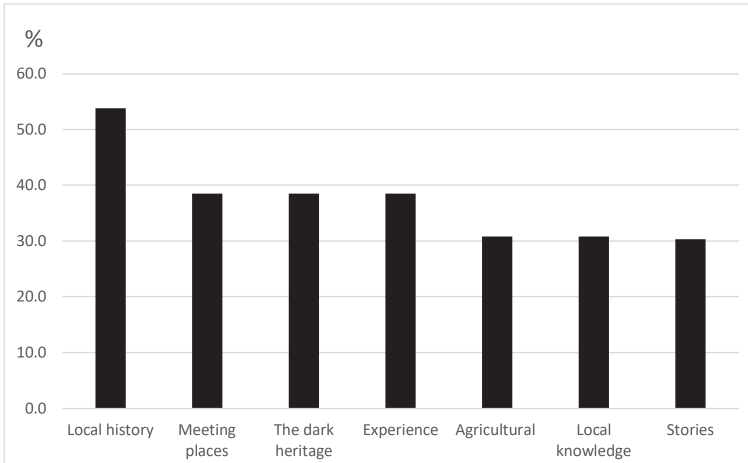

Figure 3. The x-axis shows the seven most important historic and cultural landscape dimensions that need more focus in the planning process (measured as percentage, y-axis). See also Table 1, closed-ended questions.

One of the public officials expressed a desire to "fill the historic environments with this intangible cultural heritage". At the same time, a majority of the respondents claim that they have limited opportunities to do so because of budget priorities, lack of methods and sometimes lack of skills.

3.7. Awareness, Knowledge, and Implementation of the ES and CES

All of the public officials knew about ecosystem services at the time of the interviews but only half of them worked with the ES approach. Of those who did not, several referred to the municipal ecologist and the nature conservation unit for information about ES implementation. It was clear that implementation of the ES approach had just begun. The respondents who had started to implement the ES approach responded that, at this early stage, the work was tentative and that they needed methods that can be used in the planning process. Most respondents considered the ES approach to be a benefit in the planning process but expressed a great deal of uncertainty about how to work with it and how to convince others in the organization.

The concept of cultural ecosystem services was less known. Half of the respondents had heard about CES but only a quarter had worked with it. One of the respondents who worked with CES argued that the landscape history becomes a tool for reaching out to people. The respondent used storytelling as a way to communicate the relation of the importance of the cultural-historical landscape to, for example, old wells and people's traditional use of water and herbs, including the historical monks' knowledge of the curative effect of plants. Another respondent worked with CES in a GIS-based green structure project of biotope mapping in municipal comprehensive plans. In this respect, CES was considered indirectly through sensual experiences, such as the rustling of leaves, birdsong and green leafy environments that have a direct bearing on the nature and park types that were identified. Yet, another respondent worked with CES on a GIS-based project aimed at identifying easily accessible attractive recreational environments. Here, information was used about nature and cultural reserves, areas of national interest for cultural heritage and for outdoor life, national parks, etc. The purpose was to make people understand their context, their background and their identity and the need to preserve the structures in the landscape. Even though these three examples touch upon aspects of, or are based on, historic and cultural landscape dimensions neither of them involved established knowledge of heritage planning.

Respondents argued that increased cooperation between sectors and with the civil society is the key in the implementation of Agenda 2030 and ES. An example of a public participation initiative at municipality level to communicate ES and CES via the national environmental quality objectives was through outdoor events for the public. The basic idea is that people should experience ecosystem services directly in the landscape. One example of an environmental station event was based on the environmental quality objective, "Flourishing lakes and streams". The event was located at Lake Vänern and the municipality invited the public and offered four different dishes (450 portions) of fish (Zander also named pikeperch). A professional angler made a presentation about Zander fishing, what it looks like and what actions are implemented to make the fishing industry sustainable in Lake Vänern. Additionally, representatives from the County Administrative Board and the biosphere reserve office took part in the event. Cooperation between different actors in the biosphere reserve is the key solution, as expressed by one respondent:

> "The events are under the auspices of the municipality although the biosphere office and County Administrative Board are involved players. We invite them and they become part owners of these project ideas and arrangements. Thus, we get a greater efficiency and gain more expertise when we create the events. It is important to find a form of co-creative processes so that everyone feels that they own the products. If you have confidence in each other, it will give results."

A new initiative for cooperation between different actors within the biosphere reserve is a ES network established a few years ago by a public official at municipality level in order to increase ES cooperation between the three municipalities in the biosphere reserve. The motive was to find a structure for the ecosystem services in the historic landscape and to find a horizontal platform where you trust each other and find common targets. The ES network consists of representatives from the three municipalities, the County Administrative Board, the biosphere reserve office and two nature conservation associations. The ES network meets regularly and has applied and received funds for training projects in ecosystem services for politicians, public officials and developers working within the biosphere reserve. The ES network sometimes invites researchers and actors working with historic and cultural landscape dimensions to their meetings, but they are not regular members of the ES network.

4. Discussion

4.1. Opportunities and Challenges to Ensure Consideration of the Historic and Cultural Dimensions of Landscapes

The results show that the historic and cultural landscape dimensions are important aspects in the early stages of the planning process at local and regional levels. This is partly due to current legislation, as consideration of the cultural environment is primarily governed by the Planning and Building Act, but also by the Roads Act and the Act on Railway Construction. The Swedish environmental quality objectives also contain requirements for consideration of the cultural environment. In combination with the respondents' long tradition of considering man's use of nature with an integrated landscape perspective this gives a good potential to ensure consideration of historic and cultural landscape dimensions in environmental planning. These results are in line with a parallel study in the Swedish mountains showing that practitioners strive for an integrated management of historic and cultural landscape dimensions and that these values are considered throughout the planning process [21]. One could argue that these results are in contrast to many previous studies showing a limited consideration of historical and cultural perspectives in environmental planning [1–9]. However, there is a clear conceptual ambiguity among respondents who define historic and cultural dimensions of landscapes quite differently, ranging from predominantly material aspects protected by law to intangible aspects, which are not as effectively managed in planning contexts. The respondents do not understand, nor talk about, landscape complexities in a consensual manner.

Furthermore, lack of methodologies to include local communities other than through formal consultation in the planning process makes the intangible and socio-culturally perspectives on landscape less dominant, which is the norm in the Swedish context [20,60]. This is in line with previous research highlighting the need for local participation in order to manage cultural landscapes [7,61–63]. Other challenges identified in the present study are unclear assignments and lack of political policy as well as unawareness and disinterest among politicians, developers and the public. The public officials expressed a wish to promote political decisions that connect historic and cultural landscape dimensions to environmental planning and especially the implementation of ES in combination with training efforts. These results are in line with other studies [55,64] that argue for increased political support and capacity building initiatives in order to facilitate ES implementation in municipal planning practice. Results showing that the CES concept is far from practically implemented in policies were also reported by [39] from a survey with experts on agricultural landscapes. The ELC, with its landscape policy focusing on sustainable development and the cultural dimensions of the landscape [65] is important in this respect. However, the results show that only a third of the public officials interviewed used ELC for guidance. This result is in line with previous studies showing a limited impact of ELC in practice [21,66,67]. Another challenge identified is that the idea that historic and cultural landscape dimensions belong to a certain department, such as the planning department, is deeply rooted among public officials. Professional roles and responsibilities are established mainly because of sectoral funding and the organization. These results confirm previous studies showing that, despite its integrative ambition, implementation of the ES concept often lack horizontal integration between sectors and is highly influenced by established endorsed professional roles and responsibilities in land-use planning [16,21,38,56,68].

4.2. Heritage Planning and the ES Approach

Heritage values, place identity, landscape views, local history, local knowledge, stories, and sensory experiences are examples of historic and cultural landscape dimensions that were regularly addressed in local and regional planning in the present study. These intangible landscape dimensions fit into the six categories of CES, defined by [26], but the respondents did not label them as CES. The public officials regularly worked with, and highlighted, the importance of intangible landscape dimensions and expressed a desire to work more with these values. Moreover, most public officials have a long tradition of considering man's use of nature with an integrated landscape perspective. These results are in line with [21] who show that local history, identity, stories and collective memory are aspects regularly considered by officials, in the County of Jämtland Sweden, and practitioners also strive, despite difficulties, to use a coherent landscape approach in planning. An integrated landscape approach to planning is in line with the ES approach and would facilitate a closer collaboration between actors involved in heritage planning and the ES implementation. Nevertheless, at the time of our interviews, established knowledge and expertise of heritage planning was not activated in the implementation of the ES approach. Respondents expressed that CES, are generally difficult to concretize, and thus are given less consideration than other ecosystems services. These results are in line with previous findings showing a limited consideration of cultural heritage within ES research and practice [21,25,32,41,42].

There is certainly an opportunity to connect heritage planning with the ES approach. This, however, requires a clarification and mapping of actors working with historic and cultural landscape dimensions within the regional and local agencies, NGOs and civil society. It is especially important to identify actors who do not consider themselves as working with the "right" aspects of heritage or the "right" department/organization. The definition and role of CES in the ES approach must be developed in order to be able to connect skills and create new forms of collaboration integrating historic and cultural landscape dimensions in environmental planning. A neutral platform could support the connection of historic and cultural landscape dimensions and ES in sustainable environmental planning. Several of the respondents interviewed argue that the Lake Vänern Archipelago Biosphere Reserve could be an arena for a new understanding of the landscape, beyond the established permanent division between nature and culture in formal environmental planning. However, as shown by [69], it is only a few of the public officials at local and regional planning levels that regularly cooperate with the biosphere reserve organization. The need to "create communities of practice", with shared goals in the implementation of ES and sustainable development was suggested by [38]. The new ES network, established by public officials at municipality level in the Lake Vänern Biosphere Reserve, has successfully created new forms of collaboration and an extended dialogue about ES between various actors at different levels, including training programs for politicians and developers. Even though the ES network sometimes invites researchers and professionals working with historic and cultural landscape dimensions these actors are not regular members of the ES network. Ideally, a network for ES implementation needs to include actors with different knowledge and perspectives to meet the basic requirements of the ES approach, i.e., all four categories of ecosystem services must be considered to reach sustainable development.

Municipal heritage planning would also most probably benefit from a closer connection to the ES framework. The critique against the artificial separation between natural and cultural heritage is well established in research and practice, and in the wake of "embracing this dissolution" [70], new methods and tools for more inclusive landscape interpretations are being developed. In such system-based approaches, the connections and benefits of heritage tied to natural resources are explored [71] (as well as the role of "living heritage" in socio-ecological systems [72]. These value-driven approaches are grounded in an understanding of the cultural landscape to include both man-made and non-human-made structures, and they often require a combination of qualitative methods to enable evaluation of CES, such as stated preference methods, workshops, etc. Although public participation has been on the heritage planning agenda since the 1990s, it is still an "unfixed, uncertain and contested concept" [60], and not practiced in everyday planning situations. This is in line with [7] who argue that management strategies and conservation policies based exclusively on decision-makers criteria are counterproductive for the conservation of cultural landscapes. Participatory ES assessment methods currently being developed for local resource users to identify and evaluate the key services of a particular ecosystem, including heritage, could be a way forward.

4.3. Concluding Remarks

Are historic and cultural landscape dimensions ignored in environmental planning? The price of ignoring these values is an unsustainable environmental planning and according to literature historic and cultural perspectives often have little significance in environmental planning. However, only a few studies take a deep dive into practice and study the work and perceptions of practitioners. The present study contributes to increased knowledge about the role of historic and cultural landscape dimensions in sustainable environmental planning and the compatibility and commonality of the fields of heritage planning and the implementation of the ES approach. In contrast to many other studies, we can conclude that historic and cultural landscape dimensions were considered important by practitioners who in general had a holistic view of the environment where nature and cultural values of the landscape are interdependent. However, in line with previous studies, several challenges exist throughout the planning process as shown above. Our conclusion is that historic and cultural landscape dimensions are not ignored in practice, but there is a need to articulate these aspects more clearly in order to achieve sustainable environmental planning. Established knowledge and expertise of heritage planning was not activated in the implementation of the ES approach. Interesting is, however, that the practitioners worked with intangible landscape dimensions, which can be defined as CES. Thus, there is an unexplored opportunity to connect skills and create new forms of cross-sectorial collaboration between heritage planning and the ES approach. Results and conclusions presented in this paper are in line with results from a parallel study in the Swedish mountains [21]. The agreement between these two studies strengthens the validity of the results but a validation through future interdisciplinary studies of the work and perceptions of practitioners in other parts of the world is welcomed.

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heritage

Article

Applying ICOMOS-IFLA Principles for the Conservation, Management and Reuse of a Historical Hydraulic System: The No-Ras Qanat in North-Western Iran

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Abstract: Historical hydraulic systems represent a significant part of landscapes and global heritage. However, from the second half of the 20th century onwards, substantial socio-economic as well as technological changes occurring worldwide have put them at risk of abandonment and, eventually, of disappearing. Recent studies and international conventions, including the ICOMOS-IFLA, framed historical hydraulic systems and water management techniques in a new dimension, not only as an element of the past to be preserved but an active element to achieve sustainable economic development and mitigate climate change. Those qanats or karez represented a major historical hydraulic sustainable solution for irrigation, providing a water supply, which during the last few decades, has been slowly replaced with modern, although polluting and unsustainable, technologies. Building on the recent ICOMOS-IFLA Principles Concerning Rural Landscape as Heritage and the recommendation provided by initial research, this paper aims to show how qanats can become: (1) an important local and regional cultural and natural heritage; (2) a valuable economic resource; (3) an environmentally friendly system that could at least partially replace the existing polluting solution (i.e., dams and other modern infrastructures). To achieve these goals, we propose a restoration or reuse approach for the qanat based on the necessity of multiple stakeholders at local and national levels using sustainable materials and respecting the different values as a heritage place. Our case study is the No-Ras qanat in North-western Iran. In the conclusion, we also illustrate the relevance of the aims and methods of this paper in the light of the United Nations Sustainable Development Goals.

Keywords: qanat; Iran; historical hydraulic system; landscape heritage; ICOMOS-IFLA; conservation and reuse

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1. Introduction

1.1. Water as Power, Life and Heritage

Water represents the primary human concern and has been one of the major drivers of social, political, cultural and economic development for millennia. The access to water resources contributed to shaping and influencing decision-making from the earliest hunter-gather groups to 21st century countries [1]. Moreover, the first strategies for water manipulation for irrigation purposes, navigation and delimitation of borders emerged as early as the Bronze Age in different regions of the world, including the Near East [2,3], South America [4,5], India [6,7], China [8,9] and Europe [10,11], confirming its paramount significance from small-scale aspects of everyday life up to national scale supply by governmental bodies.

As stressed by Hein et al., water can be a multifaceted tool in support of humans [12], but at the same time, a force against which we should defend when storms or floods break out. For example, the control of river flooding and the regulation of irrigation was one of the first problems that humans had to face following the emergence of agriculture. Over the centuries, the use of water has also generated conflicts between human communities, such as the political tensions following the construction of dams along rivers crossing more countries in the Middle East [13,14] and central Africa [15,16] or so-called "water grabbing", affecting many African communities [17]. These issues are strictly intertwined with the increasing effects of climate change, representing one of the key challenges in the 21st century. However, the use of water has also led communities around the world to establish an intimate link with it and its benefits. Rivers, lakes and seas have become an integral part of human life and to confirm this deep relationship, stories, traditions and rituals emerged [12,18]. For example, the hydraulic network at Angkor Vat served both the physical infrastructure and the ritual network of sacred places and temples [19]. In the Netherlands, the water management infrastructure represents an iconic element of Dutch historical identity [20]. The key role of water in all aspects of life has also been emphasized in the case of several indigenous Aboriginal Australian communities through the term "cultural water" [21,22]. In other words, water has become heritage.

Today, this can be viewed as both a heritage under threat in many parts of the world due to multiple recent human-induced factors and an active player with a critical role in the mitigation of climate change effects when responsibly used (for example, reconsidering old management systems).

Building on these reflections, this paper aims to investigate a particular type of water heritage: historical hydraulic systems (hereafter HHSs).

1.2. Historical Hydraulic Systems as Landscape Heritage

HHSs represent a significant part of rural landscapes and the wider global heritage. According to the geographic location and climate conditions, different types of HHSs have been developed by local communities worldwide. The necessary technical knowledge to build, preserve and manage these HHSs has been passed on for centuries from generation to generation and, over the long term, they have become shared tangible and intangible heritage practices. In addition to being an important cultural asset, HHSs also played a key role in the economy of numerous communities for centuries if not millennia and, in most cases, until a few years ago [23,24].

However, from the second half of the 20th century onwards, substantial socio-economic as well as technological changes occurring at different scales worldwide have put many HHSs around the world at risk of abandonment and eventually of disappearance [25–27]. This issue has slowly come to the fore, thanks to the efforts of international institutions, such as UNESCO (United Nation Educational Scientific and Cultural Organization), ICOMOS (International Council on Monuments and Sites) and IFLA (International Federation of Landscape Architects), as well as numerous researchers worldwide. As a result, a number of conservations and management guidelines for historical landscapes (which include HHSs) emerged during the last few decades, issued by international institutions, including the World Heritage Convention [28], the European Landscape Convention [29] and the Krakow charter [30].

More recently, new studies and international conventions allowed researchers to take a step forward in the understanding of historical landscapes. These have been framed into a new dimension, not only as a passive element of the past to be preserved but also as an active resource to achieve sustainable development and mitigate climate change [31]. Therefore, as stressed by [32], this kind of heritage should not be seen as a burden for the present but as a resource to build a sustainable future and counteract the growing effects of climate change. A systematic definition of the wider role of historical landscapes was provided by the recent ICOMOS-IFLA *Principles Concerning Rural Landscape as Heritage* [33], which recognized them (including HHS) as a resource that can provide food, raw materials and a sense of identity involving economic, environmental, cultural and social aspects. Interpreting HHSs as system of heritage networks connected by functional, physical, social and cultural relationships [34] allows one to overturn previous narratives concerning the passive role of landscape and environment in general, toward an active function in the overall improvement in life quality. Yet, the heritage dimension of HHSs may also contribute to issues typical of metropolitan areas, including the unregulated urban development and the overall environmental quality. It can offer a number of opportunities for urban populations, such as access to new public spaces, promotion of activities related to the memory and agricultural identity modifying the relationship between rural and urban contexts [32].

The importance of preserving and reusing HHSs has been underlined by several UN Sustainable Development Goals (hereafter SDGs). According to ICOMOS *SDG Policy Guidance* [35], HHSs are an important tangible cultural heritage falling into SDG 11.4 "*strengthening efforts to protect and safeguard the world's cultural and natural heritage*". Moreover, many HHSs are managed through communal initiatives that have been passed down from the past to the present through interactive activities (SDG 4, lifelong learning). Yet, the use of water resources and ingenuous hydraulic systems that are often forgotten and underutilized contributes to SDG 6 (Clean Water and Sanitation) scope and, eventually, to adjust climate variability, thus, matching SDG 13 (Climate action) goals. The effect of the evolution of the concept of historical landscape is also mirrored by the number of calls by the new Horizon Europe program, focusing not only on the preservation, but also on the reuse of natural and cultural heritage as well as on traditional techniques to counteract the effects of climate change [1].

1.3. Historical Hydraulic Systems and Climate Change: The Qanats/Kariz

Among the numerous examples of HHSs, a key role is played by the so-called qanat or kariz. This is an ancient system of underground tunnels and wells built for channelling water from a mountain to a generally dry lower region for multiple purposes, including irrigation and drinking water for humans and animals [36–39]. While there is no clear etymological evidence for the qanat or karez (others named it foggara, mayun, negula, etc.), the majority of studies agreed that it might be a Persian or Arabic word meaning "tube", "canal" or "channel" [38–41].

This underground water system represented a major technological solution for water supply in arid and semi-arid regions for millennia [37,39,42], with the earliest archaeological evidence placing its emergence either in the Zagros mountain in the west of Iran [42,43] or southeast Arabia [44,45]. Then, thanks to their multiple social and economic benefits, qanat-like systems spread throughout the Middle East [46] and in many arid and semi-arid regions of China [47,48], the Mediterranean basin [49,50], Northern Africa [42,51] and South America [52].

The specific technical knowledge for construction, management and maintenance gave rise to professional figures called (at least in the Middle East region) *moqanni*, whose skills have often been handed down from father to son for generations [37]. The great engineering and economic value of these works was recognized in ancient times, as confirmed by the Neo-Assyrian chronicles of King Sennacherib [53,54], which brought artisans to Assyria for replicating the system in order to provide water to the main cities of the empire. Entire communities grew and flourished around one or more qanats. Therefore, these HHSs have represented not only an important architectural element and economic engine but also part of the heritage of numerous communities around the world.

Despite this long-term tradition, from the 19th century onwards, an increasing number of qanat/karez have been abandoned and replaced by modern water management systems, such as dams and other hydroelectric infrastructures [36,55,56]. However, recent research brought about a growing consensus on the multiple, often irreversible, issues inherent or caused by most of these modern systems, including pollution and other environmental damage, regional conflicts, political pressures, as well as structural instability [13,14,36,57,58].

Today, qanats/karez are documented in 34 countries around the world [59]. In terms of quantity and dimensions, Iran is the richest country, with almost 24,000 qanats located in the arid and semi-arid dry areas. To help counteracting this phenomenon, over the last decade, a growing number of scientific papers emphasized how the use of HHSs, including qanat/karez, integrated with modern clean and sustainable methodologies and tools, can become a valuable economic, environmental, social and cultural resource [37,42,60]. Moreover, while detailed studies are still underway, numerous researchers are also stressing the relevance of qanats and similar HHSs to counteract the effects of climate change, often caused by modern hydraulic systems [61,62]. The importance of preserving and reusing these HHSs has been recently confirmed also by UNESCO and FAO (Food and Agriculture Organization of the United Nations). Five UNESCO World Heritage Sites (WHSs) [2] and two FAO Globally Important Agricultural Heritage Systems (GIAHSs) [3] located in Iran or Spain are, or include, one or more qanat/karez.

1.4. Applying the ICOMOS-IFLA Guidelines for Documenting, Preserving and Reusing HHSs

The present research builds on a previous paper [36], which analysed the case study of No-Ras qanat, in the Tabriz region of North-west Iran as an example of an HHS at risk of abandonment and decay, that is instead an important cultural and natural heritage (as demonstrated by the UNESCO WHS qanat system of Yazd in central Iran) and that can newly represent a valuable economic resource, also enhancing and reviving the urban layout of a town.

The analysis proposed in that paper regarded the first part, known as "*Principles*", of the guidelines presented by ICOMOS-IFLA [33] and discussed by Scazzosi [34].

The "Principles" phase primarily consists of the definition of the heritage elements and their importance. Moreover, it also takes into account the threats, challenges for conservation as well as the benefit for stakeholders and in terms of a place's sustainability [34]. For our case study, we considered the qanat within its geographic context, considering both tangible and intangible permanencies, the role and involvement of the different stakeholders, the spatial character, the previous and current threats, along with the attitude toward change. We then provided several recommendations, revolving around five key issues, for drafting an efficient action plan, representing the second part of the ICOMOS-IFLA document [33]: 1. water shortage; 2. mismanagement and lack of documentation; 3. loss of technical skills; 4. lack of awareness; 5. perception of qanat as cultural heritage.

This paper focuses on the second part of the ICOMOS-IFLA methodological approach to HHS, meaning the "*Action criteria*". Based on the recommendations proposed in the first part, we will provide an action plan for preserving and reusing the No-Ras qanat.

2. Aims and Methods

2.1. Aims of the Research

The wider aim of this article is to contribute to enhancing the debate on the sustainable solutions for water management and the mitigation of climate change effect, based on the conservation and reuse of traditional systems also in urban environments. This will be achieved through a number of specific aims showing how the No-Ras qanat can become: 1. an important local and regional cultural and natural heritage; 2. a valuable economic resource; 3. an environmentally friendly system that could at least partially replace the existing polluting solution (i.e., dam and other modern infrastructures).

These can eventually contribute to meet specific SDGs, in particular, 11.4 (wider aim 1), 4 and 6 (wider aim 2) and 13 (wider aim 3). The wider aims will be achieved by applying the second stage of the methodological approach to rural landscapes, named "*Action criteria*" proposed by the ICOMOS-IFLA *Principles Concerning Rural Landscape as Heritage* [33].

2.2. Methods

The methodology used in this paper starts from the five issues and recommendations provided in Branduini et al. [36] (Table 1). For identifying these issues our previous research, Branduini et al., applied a multidisciplinary approach including landscape architecture, archaeology, remote sensing, engineering and ethnography fields of study [36]. In particular: (1) Landscape architecture and archaeology were used to conduct a thorough territorial and land-use analysis which highlighted the changes in the relation between the Tabriz urbanscape and the surrounding rural area which included also the No-Ras qanat. (2) Multi-temporal satellite imagery remote sensing was crucial for understanding the long-term damages to the qanat. (3) Engineering provided significant support for the structural analysis of the qanat. (4) Ethnography helped to understand the connection of the local community with the qanat through the perception and awareness analysis.

Table 1. Research methodology. Both Issues and Recommendations are from Branduini et al. [36]. The ICOMOS-IFLA Action criteria are taken from ICOMOS-IFLA [33]. RWWTC means Regional Water and Wastewater Treatment Company, RAJO means Regional Agricultural Jihad Organization, ICHHTO means Iranian Cultural Heritage, Handicrafts and Tourism Organization, while MCHT means Ministry of Cultural Heritage and Tourism.

Issue	Recommendation	ICOMOS-IFLA Action Criteria	Activities Proposed	Actor	Beneficiary
(1) Mitigate water shortage	Local institutions promoting assessments to compare the cost/benefits of modern hydraulic infrastructure and qanats If qanats result in a successful water supply, develop a collaborative and sustainable water management plan	**B.3** Defining strategies and actions for dynamic conservation, repair, innovation, adaptive transformation, maintenance, and long-term management **C.5** Finding a balance between long-term conservation and short-term needs	Assessment of cost/benefits of the current hydraulic infrastructures (B.3) Planning and implementing conservation and enhancement activities (B.3) Development of a water management plan (C.5)	RWWTC RAJO University Municipality	Local farmers
(2) Mis-management and/or lack of document	Constant monitoring and application of damage assessments by public and/or private research institutes	**A.5** Developing knowledge to enable comparison of rural landscapes at all levels **B.6** Preparing monitoring strategies	Creation of an association/council for managing and monitoring the No-Ras qanat (A.5 and B.6)	RWWTC RAJO Municipality	Local farmers Moqannis and other professionals working in/for the qanat
(3) Loss of technical skills	Joint collaboration between local farmers, Regional Agricultural Jihad Organization, and external moqannis for keeping the knowledge	**A.6** Recognizing local populations as knowledge holders **B.4** Consider economic, social, and environmental values **C.2** Recognizing key stakeholders for rural landscapes, including rural inhabitants	Training courses for moqannis and professional figures working in the qanat (A.6 and C.2) Investment in non-invasive sustainable technologies to improve qanat efficiency (B.4)	RWWTC RAJO Local farmers Council of No-Ras qanat	New moqannis and other professionals working in/for the qanat
(4) Lack of awareness	Increasing the synergy between universities and local farmers, possibly with the support of the government, in creating projects and associations for the protection and communication of the importance of qanat	**C.4** Considering interconnections between landscapes **D.1** Communicating awareness **D.2** Increasing awareness	Developing signals and panels (D.1-2) Organizing visits to the qanat for children, families, schools, etc. (D.1-2) Organizing conferences and meetings (D.2, C.4) Creating webpages and other online tools (D.1-2)	Universities Local farmers Municipality MCHT Council of No-Ras qanat	Local community
(5) Qanat as a heritage	Collecting info about the history of the qanat Applying different communication strategies Involve local communities in conservation activities	**A.4** Inventory and catalogue rural landscapes at all scales **A.7** Promoting cooperation for research **D.3** Supporting shared learning, training, and research	Scientific research on the history of the qanat (A.4, A.7, D.3) Interviews to collect oral history (A.7, D.3)	Universities Local farmers MCHT Council of No-Ras qanat	Local community

Each issue and recommendation was associated with one or more action criteria listed by the ICOMOS-IFLA guidelines [33].

Based on this, we defined tailor-made activities also identifying actors and beneficiaries. In this way, we aim to move from a traditional top-down approach to a project co-construction [32] promoting the participation of the public and the government in the mutual elaboration of a landscape project [63]. Moreover, in line with ICOMOS-IFLA guidelines updated interpretation of heritage, we aim to open a discussion on how heritage and its values can help to establish alignments and objectives in terms of economy, social cohesion and environmental protection, creating, in the process, awareness, sense of place and identity in its inhabitants and visitors [60]. A detailed description of the activities, actors and beneficiaries will be provided in Section 3.

2.3. Case Study: No-Ras Qanat in Northwestern Iran

We applied this methodology to the No-Ras, located in North-western Iran, on the outskirts of modern Tabriz (Figure 1). It is about 3.5 km long and runs from the slope of Sahand mountain near the village of Chavan to the outlet located in the Fath Abad garden (Figures 2 and 3A).

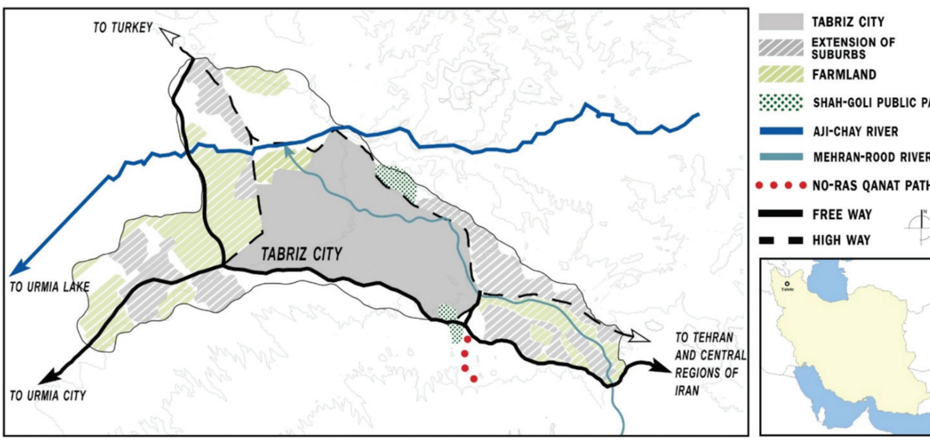

Figure 1. The Tabriz area and the No-Ras qanat (after [36]).

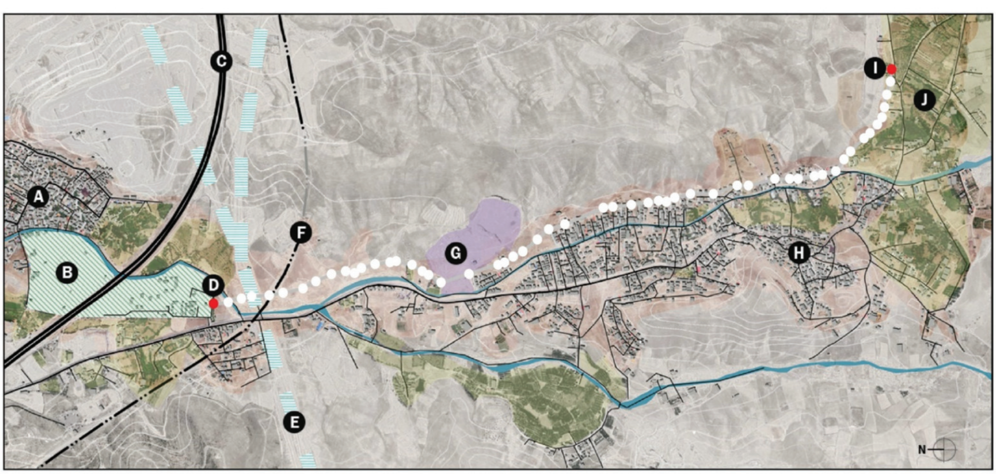

Figure 2. The No-Ras qanat; (A) Fath-Abad village; (B) Fath-Abad historical garden (downstream); (C) freeway; (D) outlet/Mazhar (red dot); (E) gas pipeline; (F) train line; (G) sand and gravel mine; (H) Chavan village; (I) mother well (red dot); (J) agricultural lands (upstream).

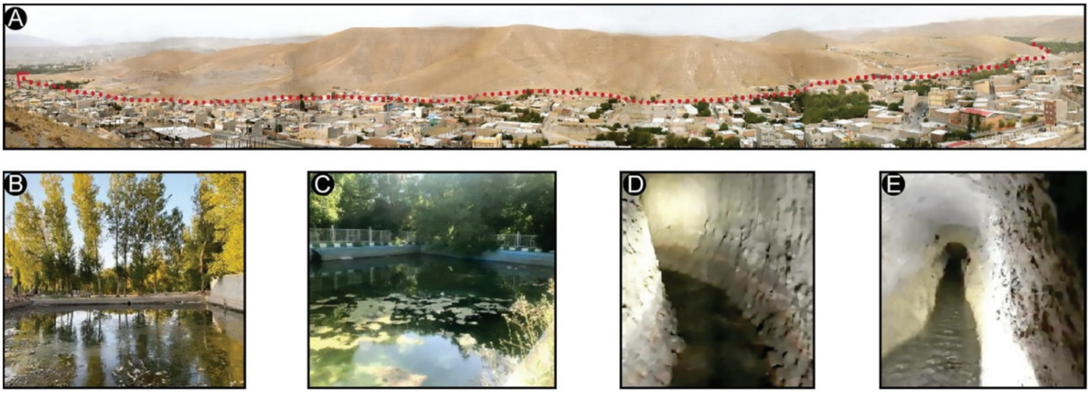

Figure 3. The No-Ras qanat. (**A**) Reconstruction of the path in the area of the Chavan village; (**B**,**C**) outlet and pool inside the Fath Abad garden; (**D**,**E**) the underground water system.

The use of the No-Ras qanat is attested as early as the 13th century CE [64], as part of the numerous hydraulic activities carried out by Khajeh Rashid Al-Din Fazlullah during the Mongolian rule over the region. Its construction helped to transform at least part of the dry hilly area south of the city of Tabriz into a fertile land with gardens (i.e., the Fath Abad garden) and cultivated fields. This is also confirmed by Martin et al., who emphasized how the overall plan for the improvement of hydraulic facilities (including the No-Ras qanat) fostered the economic and social development of the region which became a prosperous rural residential area, with facilities and extended farmland [65]. While the political situation in the region remarkably changed through time, this HHS remained in use for almost seven centuries. Today, while at risk of abandonment and slow decay, recent research demonstrated that the No-Ras qanat still holds an important historical value for both the elders of area, the historians and other academic researchers interested in the subject [36]. Moreover, it represents a critical source bringing significant economic benefits to the local farmers and the local authorities, in particular those in charge of the maintenance of the outlet located at the Fath Abad garden [36].

From the pool inside the garden (Figure 3B,C), the underground water system (Figure 3D,E) flows through the Fath Abad village and the surrounding farmland. The No-Ras qanat has 54 wells including the mother well, located at a regular distance of about 60 m. Nowadays, only 11 of these wells can be recognized and just four of them are accessible and open, while the rest are blocked. Several wells have been destroyed by seasonal floods (which also affected part of the gallery) while others were blocked by new owners or fenced within private buildings. The deepest shaft is the so-called “Mother-well” reaching 49 m in depth. Most of the qanat route passes through the village of Chavan and the life and urban development of this small village (counting less than 2000 inhabitants) are strongly interconnected with the (albeit partial) use of the No-Ras. For example, numerous wells are located within the private properties of villagers and many local farmers who exploit the waters of the qanat come from it. Chavan and its inhabitants will, therefore, be carefully considered in the conservation and reuse proposal of the qanat.

The historical relevance of the No-Ras qanat was partially recognized from 1996, when its last stretch, including the Fath Abad garden, the outlet and the historical Garden Mansion were registered in the Iran National Heritage List. This brought to the restoration of the mansion the Fath Abad garden and part of the outlet. However, while the historical mansion was restored according to non-invasive approaches, thus, respecting the architectural layout and the original decorations, both the garden and the outlet were highly modified due to highly invasive methodologies [36]. Further risks, highlighted by Branduini et al., that over the last 20 years increasingly threaten its stability and the possibility of fully reusing it include [36]: buildings and roads construction, soil removal and levelling, ploughing, pollution and lack of maintenance. These are connected to the five issues illustrated in Table 1 and for which this paper proposes solutions.

3. Preserving, Managing and Reusing the No-Ras Qanat

In this section, we describe, in detail, the actors, beneficiaries and the activities that are proposed for the conservation and reuse of the No-Ras qanat, based on the guidelines of the ICOMOS-IFLA document. In fact, although the project has not started yet, numerous contacts with these actors have started and the feasibility of the proposed activities has, so far, been positively evaluated. It is crucial for the design, conservation, management and reuse strategies of the qanat to consider all the stakeholders, their skills, necessities and added value. To facilitate this, Salek [66] recently proposed to apply Actor-Network Theories (ATN) [67,68] to the specific case of qanats to develop a solid network of stakeholders (in our case, defined as actors and beneficiaries). For the scope of our study, ATN stages will be applied to different activities. For example, Sections 3.1 and 3.2, aiming at identifying the actors and beneficiaries, their function, interconnections and necessities in relation to the No-Ras qanat, are consistent with the earliest phases of the ATN, named *Problematization* and *Interessment*.

3.1. Actors

Here, we provide the details of the actors already identified during the Principles phase [36] that will play an active role in the individual activities envisaged. Most of them are the same identified by UNESCO and the Iranian Cultural Heritage, Handicrafts and Tourism Organization (ICHHTO) for the national qanats recognized as WHS [69]. For each of them, we specify the role and purpose:

1. Ministry of Cultural Heritage and Tourism (MCHT): It is the educational and research body overseeing museums, archaeological sites and monuments throughout Iran. One of its branches, ICHHTO, is in charge of managing the qanat at the national and regional levels. Therefore, we believe that the MCHT will be essential for officially supporting the communication and promotion of the cultural value of the qanat at local, national and international scales. In addition to the overall supervision and approval of the activities related to the qanat restoration and reuse, the MCHT will have a primary role in raising awareness of the importance of the qanat (Group of activities 5) and its relevance as heritage (Group of activities 6).
2. Regional Water and Wastewater Treatment Company (RWWTC): It is a national organization with numerous regional offices in charge of monitoring and developing water and wastewater grids and monitoring the status of urban wastewater treatment systems. They will be involved in restoration and reuse (Group of activities 1), development of efficient management strategies (Group of activities 2) and training (Group of activities 3).
3. Regional Agricultural Jihad Organization (RAJO): This organization is also in charge of dredging, repairing, reconstructing and developing the Qanat. While their contribution will be crucial over the entire process, together with the RWWTC, they will be mostly involved in restoration and reuse (Group of activities 1), development of efficient management strategies (Group of activities 2) and training (Group of activities 3).
4. Municipalities: The municipalities of both Tabriz and the village of Chavan represent an important connection between the local communities and the national and regional institutions. They can act as a bridge, facilitating the smooth and clear implementation of the procedures. In our case, based on the recommendations, we believe that they will be important for developing the qanat management protocol (Group of activities 1) for the development of efficient management strategies (Group of activities 2) as well as for contributing to raising awareness of the importance of the qanat (Group of action 4).

5. University: The main research institution of the region is the University of Tabriz. It is one of the most important academic institutions in the country with a wide range of specializations, including agriculture, economy, architecture, engineering and history. Therefore, they can be of the greatest support for finding modern technological sustainable solutions for the qanat restoration (Group of activities 1) as well as for contributing to raising awareness on the importance of the qanat (Group of action 4) and its relevance as heritage (Group of activities 5).
6. Local farmers: These include native people and old immigrants, especially those living in the village of Chavan and Fath Abad, whose main jobs are related to farming, gardening and animal husbandry. They have a good understanding of the value of qanats, which they have extensively used for the irrigation of cultivated lands and gardens as well as for supplying water to their livestock. Their commitment towards the preservation of the qanat is very strong and includes the organization of protests against the heavy damage caused by the sand and gravel mine [36]. Although actively involved in all phases of the project, their qualities will make them important actors to train new professional figures (Group of activities 3) and to raise awareness on the multi-perspective relevance of the qanat (Group of action 4), including heritage (Group of activities 5).

3.2. Beneficiaries

Below, we provide details of those stakeholders already identified during the ICOMOS-IFLA *Principles* phase [36], who will benefit from the activities planned. For each beneficiary, we specify the role and purpose:

1. Local farmers: As beneficiaries, they will benefit from all activities related to water shortage mitigation (Group of activities 1), mismanagement (Group of activities 2) and loss of technical skills (Group of activities 3).
2. New moqannis and other practitioners working in/for the qanat: They include the craftsmen specialized in the construction and maintenance of the qanats. The work of the moqanni is usually inherited from father to son or continued among family members [37]. While receiving benefits from all the activities foreseen, they will particularly profit from those related to mismanagement (Group of activities 2) and loss of technical skills (Group of activities 3).
3. Local community: Primarily consisting of the people who live around the Chavan village along the qanat, down to the Tabriz suburbs. Although they will also benefit over the long term from group of activities 1–3, we plan to help them improving their awareness towards the economic benefits and the environmental value of the No-Ras qanat (Group of activities 4), together with the heritage value (Group of activities 5).

3.3. Activities

In this section, we detail the single activities listed in Table 1 that are in course of being proposed or approved by the above-mentioned actors. We organized the activities in different groups, each one addressing the issues and recommendations that emerged in the initial research [36]. For example, “Group of activities 1” refers to “Issue and recommendation 1”, etc.

3.3.1. Group of Activities 1

The recommendation proposed matches Action criteria B.3 and C.5 in the ICOMOS-IFLA document. Therefore, we designed specific activities to meet their requests. For Action B.3, “*Defining strategies and actions for dynamic conservation, repair, innovation, adaptive transformation, maintenance and long-term management*”, we propose two types of activities:

- Assessment of costs and benefits of the current hydraulic infrastructures. This type of analysis must be conducted by the RWWTC, RAJO and the local Municipality in collaboration with the local farmers, who also represent the final beneficiaries. There are currently several approaches to assessing similar situations. Among those, both cost–benefit analysis (CBA) and cost-effectiveness analysis (CEA) are increasingly applied to archaeological sites, monuments and other heritage places [70,71], while Contingent Valuation (CV) may help in estimating the expected benefits from the qanat for the local residents [72].

- Planning and implementing preservation and enhancement. The first step regards stopping or modifying all those activities, potentially directly or indirectly, damaging the qanat located within the 15 m buffer zone and, therefore, non-compliant with Iranian law for the protection of cultural heritage as well as the UNESCO regulation for WHS in Iran (Figures 3 and 4). To this end, the qanat area was divided into five sectors, three of which are characterized by a specific type of threat. The upstream sector, defined as "Upstream agricultural fields", does not present immediate risks, although restoration activities of the qanat structure are necessary. Moving towards the valley, the second sector (Figure 4D) corresponds to the northern part of the village of Chavan. Here, 80 buildings are located within the 15 m buffer zone. The majority of buildings include small residential units (22%) or non-used/abandoned ones (30%), while only 7% consist of small-scale industrial complexes. The third sector (Figure 4C) is the one threatened by the mining area, while in the fourth one, the main issues are represented by the railway (Figure 4A) and gas pipeline (Figure 4B) and their debris. While we acknowledge the difficulty of moving a railway and the pipeline, it would be advisable to lift it, thus, making a bridge over the qanat path, so as to substantially reduce the vibrations and pressure caused by trains. The same could be for the pipeline. At the same time, to reduce the number of small vehicles, we suggest an increase in public transport connections between Tabriz and Chavan. This would also facilitate the people living outside the qanat area to easily visit and enjoy it.

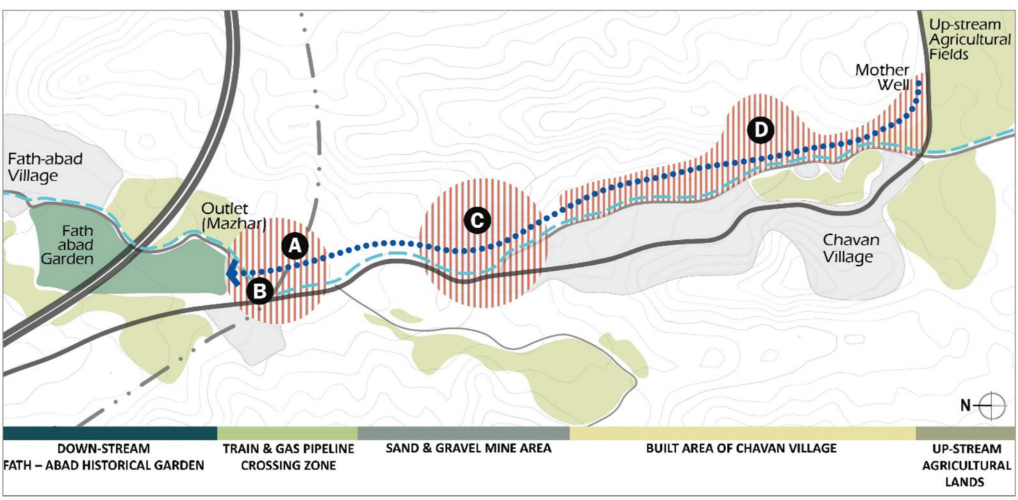

Figure 4. Main activities/structures currently threatening the No-Ras qanat stability and use. (A) Railway; (B) gas pipeline debris area; (C) mining area; (D) houses in the Chavan village inside the buffer zone.

The structures affecting the preservation of the No-Ras qanat should be removed and, if possible, relocated elsewhere. Relocation would regard the railway, the pipelines and the houses. Removal without relocation and cleaning would instead regard the mining area and the debris area around the railway line. Mining activities have already demonstrated their dangerous effects on the qanat, causing at least two collapses in the underground gallery and the well in 2008, which caused substantial protests from the local farmers and the Fath Abad authorities.

Once these structures have been removed, No-Ras qanat will be restored. This action will consist in the reopening of the more than 40 wells currently closed and the consolidation of the 11 wells in operation (including the mother well) and the underground channel. The restorations must be carried out using materials compatible (hydraulic mortar, local marl or limestone and black poplar) with the existing ones and that respect the characteristics of the original artifacts.

Once the entire qanat structure is restored and back in operation, we will proceed to the enhancement phase through a series of low-invasive targeted activities in those sectors where previous restoration and enhancement activities have not been carried out by the MCHT or other bodies (i.e., the Fath Abad historical garden).

Transversal Activities

First, the visibility that directly influences the understanding of a qanat will be improved. For this purpose, we envisaged both transversal and targeted activities for the individual sectors. Transversal activities consist of the creation of a boardwalk in selected spots along the underground tunnel, in particular, in the inhabited areas of the Chavan village (Figure 4D) and close to the Fath Abad garden (Figure 4A), located in the outskirts of Tabriz. This is designed to be a low-invasive structure (Figure 5I), mostly composed of local and natural materials, such as black poplar wood, which is also present in the Fath Abad garden. The boardwalk will allow people to walk across, understand and appreciate the multi-faceted landscape around it. To increase the visibility of qanat, next to the wells located along the boardwalk, solar tree panels will be installed together with led lams. The former (Figure 5K) directly catches the sunlight in the morning and generates electricity for lighting in the No-Ras qanat buffer zone, thus, allowing it to be accessible also during the evening.

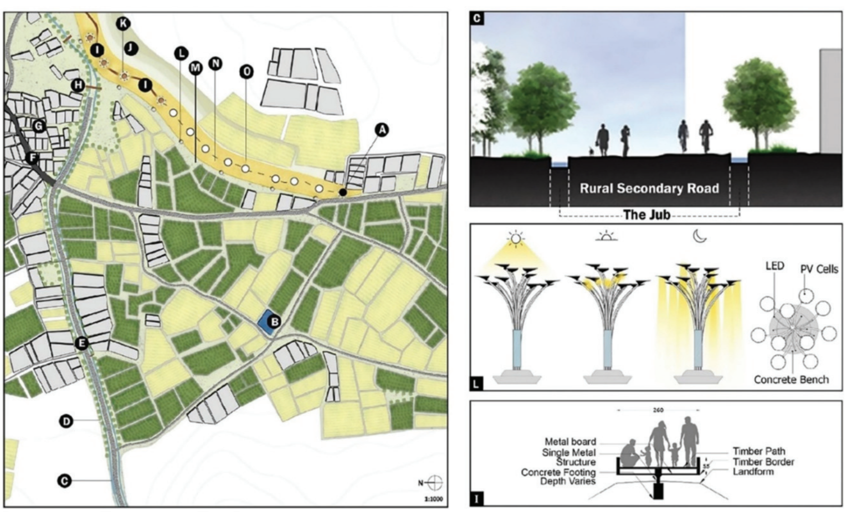

Figure 5. Proposal for the renovation of the upstream agricultural area of the No-Ras qanat. (A) Mother well; (B) storage pool for agricultural use; (C) the Jub; (D) newly planted trees; (E) rural secondary road; (F) Chavan main road; (G) Chavan village; (H) small wooden bridge; (I) boardwalk; (J) gentle hill way; (K) No-Ras qanat's wells; (L) information solar tree panels; (M) agricultural fields; (N) No-Ras qanat core zone; (O) limit of the buffer zone.

These renovations will positively impact on at least the northern neighbourhoods of Chavan. Indeed, the more rational the organization and the greater awareness towards the urban (southward) and peri-urban (northward) landscape (Figure 6), the more it will provide a place of aggregation that, as documented in several cases worldwide [73,74], will foster social inclusion, people's health and possibly the economic value of the houses.

Figure 6. Proposal for the renovation of the sector of the No-Ras qanat passing through the modern village of Chavan. (A) Gentle hill way; (B) Chavan main road; (C) boardwalk; (D) No-Ras qanat's wells; (E) centre for organic farming; (F) the Jube; (G) natural seasonal streams; (H) Chavan village; (I) rainwater storage area; (J) No-Ras qanat core zone; (K) reforestation; (L) limit of the buffer zone.

Moreover, in order to foster the understanding of the qanat hydraulic system and the wider natural and the anthropized context in which it is embedded, several information panels will be placed along its path (Figures 5L, 7G and 8I), while numerous wells will be covered with glass slabs to allow people to look inside (Figures 7C and 8B).

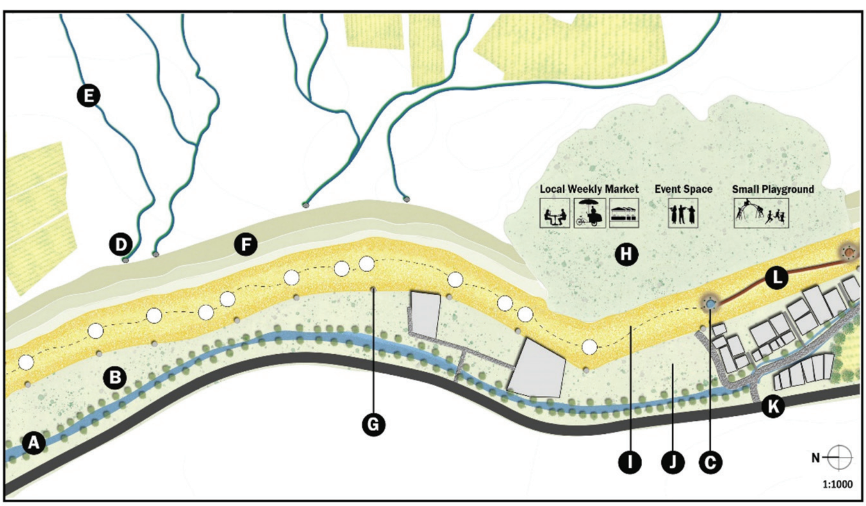

Figure 7. Proposal for the renovation of the mining sector of the No-Ras qanat. (A) River; (B) newly planted trees; (C) No-Ras qanat's wells (Glass slabs); (D) rainwater storage area; (E) natural seasonal stream; (F) hill; (G) information solar tree panels; (H) new public square for the local market; (I) No-Ras qanat core zone; (J) open areas (No-Ras qanat buffer zone); (K) Chavan main road; (L) boardwalk.

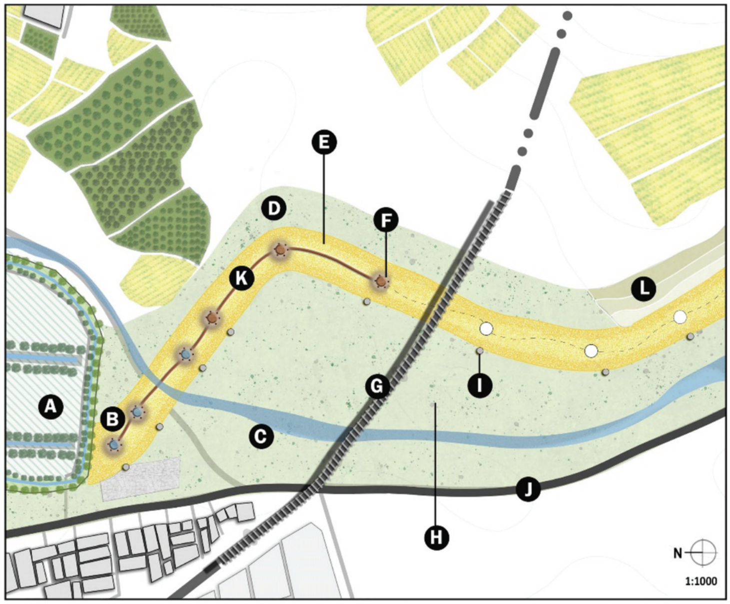

Figure 8. Proposal for the renovation of the railway and pipeline sector of the No-Ras qanat. (A) Fath Abad historical garden; (B) No-Ras qanat's wells (glass slabs); (C) river; (D) No-Ras qanat buffer zone; (E) No-Ras qanat core zone; (F) No-Ras qanat's wells; (G) new railway and gas pipeline bridge; (H) open areas; (I) information solar tree panels; (J); Chavan main road; (K) boardwalk; (L) gentle hill way.

A small seasonal river passes through the village of Chavan, flowing close to the No-Ras qanat. This river stream, running both in the upstream area and the successive ones, corresponds to the path of the secondary road (Figure 5E), which during the fall and winter seasons, is partially or fully flooded. Moreover, when running close to the qanat, it may affect its stability and access to the wells. Therefore, we propose a solution for controlling the water flow and improving the area seasonally flooded by the river. We suggest using a traditional water management system called "Jube" (Figures 5E and 6F) [75]. This consists of the division of the river into two separate streams located on both sides of the secondary road. The outer banks of the river will be strengthened by planting local trees, while the road will be kept unpaved, meaning made of the local soil.

As a traditional hydraulic system and part of the heritage of the region, the Jube will be critical for managing and preventing new floods in the northern part of the city. Moreover, the new layout will provide an important and safe roadway crossing the entire village and it will contribute to the embellishment of the area, possibly leading, over the long term, to an increase in the economic value of the buildings along it.

Target Activities for the Upstream Agricultural Area

Targeted activities regarding the "Upstream agricultural area" include the creation of a large pool for agricultural purposes, representing a traditional solution in the region for storing water (Figure 5B). Similar infrastructures are currently missing in the area and their creation would be a valuable support for local farmers, especially in dry seasons.

Target Activities for the Sector Occupied by the Chavan Village

In addition to the transversal action described above, two main activities have been planned to enhance the sector occupied by the Chavan village (Figure 6).

A first structural action, also affecting the sector occupied by the mining area, aims at protecting the qanat from the natural seasonal streams flowing from the top of the hill to the east (Figure 6G). The erosive action of the seasonal streams causes substantial damage to the qanat over time. To avoid this, we propose placing several small wells along the streams to allow for natural storage of the water. In this way, we will also provide farmers with additional water for irrigation.

A second initiative concerns the creation of a "Centre for organic farming" (Figure 6E). This center will support farmers in the development of sustainable solutions for agriculture, thus, contributing to reducing pollution generated by intensive agriculture and eventually meeting the scopes of SDG 13. The center will involve the local population through events and lectures, during which the key concepts of organic farming and their benefit for both people and the environment will be explained.

The creation of the Centre of organic farming could be supported by national funding as well as from the municipalities of Chavan and Tabriz. Scientific and technical supports may also be searched among international organizations and NGOs, including the Organic Research Centre (https://www.organicresearchcentre.com/ (accessed on 11 October 2022)) and the International Society of Organic Agriculture Research (https://www.isofar.online/Home/ (accessed on 11 October 2022)). In addition to the provision of new job positions, the novel approach of the center (i.e., promotion of organic farming) may help attracting researchers, external farmers and other stakeholders, thus, making the village an important hub for organic farming in the area. Over the long term, the center may host fairs and events, also attracting people from the entire region or nation, thus, having economic benefits for the population of Chavan and Tabriz as well.

Target Activities for the Sector Occupied by the Mining Area

In addition to the transversal activities, we propose replacing the existing mining area with a public square hosting a weekly market (Figure 7H). The square will be equipped with solar tree panels and soft park furniture lighting. The weekly markets will be organized in collaboration with the Centre for organic farming to sell the products of local farmers, promote sustainable agriculture and share the value and results of the No-Ras qanat renewal project.

A second action envisaged in the mining area will regard the reforestation of a large portion, located (Figure 6K) close to the Chavan village with local trees. This action will have a significant environmental impact, eventually contributing to meet the scopes of SDG 13. As demonstrated by numerous studies worldwide [76–79], the reforestation of the areas around villages and towns have a positive impact on the urban population, also increasing the value of buildings and possibly triggering a virtuous circle of urban improvement.

Target Activities for the Sector Occupied by the Railway and Pipeline

Most of the changes proposed for the railway and gas pipeline area (Figure 8G) fall within the transversal activities (see above). Targeted activities for this sector include the creation of two large open areas with meadows and local plants (Figure 8H) to the north and south of the qanat buffer zone. In addition to revitalizing a large area now abandoned or occupied by the railway and pipeline construction debris, the new green area will contribute to improving biodiversity and will act as a "natural" buffer zone for protecting the qanat.

For Action C.5 "*Finding a balance between long-term conservation and short-term needs*", we propose one action:

- Development of a water management plan for the No-Ras qanat. This type of analysis must be conducted by the RWWTC, RAJO and the local Municipality in collaboration with local farmers, representing also the final beneficiaries. A good reference for drafting an efficient plan are the State of Conservation Reports [69,80], issued by ICHHTO and UNESCO for the current qanat included in the World Heritage List [81]. This could be integrated with the documentation from the qanat systems of Kashan and Gonabad (both in Iran), which are part of the GIAHS network [82,83].

3.3.2. Group of Activities 2

The recommendations were drafted to match the Action criteria A.5 and B.6 of the ICOMOS-IFLA guidelines. To meet them, we designed a specific action:

- Creation of an association/council for managing the No-Ras qanat. Following the example of "The Persian Qanat" UNESCO WHS [81], we proposed the creation of a Council of the No-Ras Qanat. This body is crucial for the daily management of the qanat (while the ICHHTO manages then at the national and regional level, see above), also acting as a bridge between the local, national and regional authorities and the community, including the farmers. Furthermore, the creation of a Council represents the first stage of ATN named Enrolment [66], which is essential to strengthening the network of actors. According to the national law (Articles 17 and 106) and other reports [81] and research [66], the council structure should be composed of 5–7 members and can be "*headed by the qanat council manager (mirab) and comprising the water clock operator (kayyal), the accountant (hesabdar), together with other qanat workers generally termed moqannis and another specialists such as the bucket operator and the windglass operator*". We suggest following this example, also including the representative of the local farmers and the municipality of Chavan and Tabriz to increase inclusiveness in decision-making.

In designing the role of the Council of the No-Ras Qanat, we also took into account the ICOMOS recommendation to "The Persian Qanat" UNESCO WHS. Therefore, the council will be responsible for: 1. developing a management plan, also including monitoring strategies; 2. implementing monitoring, conservation and reconstruction activities at the qanat in collaboration with ICHHTO, RWWTC and RAJO; 3. developing and implementing a risk preparedness plan with the support of external consultants, also meeting international standards, such as the UNESCO Disaster Risk Management [84] or the Sendai Framework [85]; 4. organizing training programs for qanat employees and new candidates; 5. managing water distribution for daily use and irrigation purposes in collaboration with the municipality and the local farmers.

3.3.3. Group of Activities 3

The recommendations proposed for group of activities 3 match the Action criteria A.6, B.4 and C.2 of the ICOMOS-IFLA guidelines. Tailor-made activities were designed to meet the requests.

For Actions A.6 "*Recognizing local populations as knowledge holders*" and C.2 "*Recognizing key stakeholders for rural landscapes, including rural inhabitants*", we propose the following action:

- Training courses for moqannis and professional figures working in the qanat. To this end, the Council of the No-Ras Qanat will evaluate be necessary for hiring new moqannis or other specific jobs related to the conservation and management of the qanat. If so, training sessions supported by the Municipality (for the economic support and the bureaucratic aspects) and the local university (for the details about the qanat engineering and heritage aspects) will be organized.

For Action B.4 "*Consider economic, social and environmental values*", we proposed the following action:

- Investing in non-invasive sustainable technologies to improve qanat efficiency. The importance of integrating modern non-invasive and sustainable technologies in ancient structures and systems, such as the qanats, has been recently emphasized by the European Union by promoting "Research and Innovation Actions" within the Horizon Europe program for reusing and improving traditional heritage crafts and systems.[4] The technological improvements that could be applied to the qanats are many and, here, we provide some examples. One of them is satellite imagery, a valuable and user-friendly tool for monitoring the state of conservation of the wells when access to them is prevented (i.e., during conflicts, natural disasters or pandemics) [61,86,87]. The growing availability of open access imagery makes them more accessible and usable for everyone. Moreover, numerous researchers developed methodologies to identify and document endangered qanats [49,88,89]. Another example regards internal damage and stability that may be evaluated and mitigated through the construction of low-weight structures, spread and pile foundations or retrofitting (e.g., load decreasing, load-bearing columns and walls and load-diverting arches) [90,91]. One final solution is to keep the secondary road unpaved to avoid further spread of tarmac, using bio-enzyme products, such as Perma-Zyme, Terra-Zyme, or Fujibeton, which guarantee soil stability and the long-term durability of the unpaved road. These are economic and environmentally friendly solutions that have been extensively employed in countries, such as India [92], Egypt [86] and Australia [87]. The improvement in the current road plan will allow for a faster and simpler connection to the center of Chavan with Tabriz and the neighborhood village.

3.3.4. Group of Activities 4

The recommendations proposed for group of activities 4, "lack of awareness", match the Action criteria C.4, D.1 and D.2 of the ICOMOS-IFLA guidelines [33]. Tailor-made activities were designed to meet the requests.

For Action C.4, "*Considering interconnections between landscapes*", we propose the following action:

- Organizing visits to the qanat for children, families, schools, etc. The involvement of the local population in conservation, management and reuse activities to raise awareness on heritage and foster interconnection between urban and rural landscapes is widely recognized [88,89]. In our case, we suggest that the new-born Council of the No-Ras should work together with the different actors, including the local university, farmers and the municipality of Chavan, to organize visits to the qanat and events targeting schools and families and other members of the Chavan and Tabriz community. This activity also matches action D.2.

For Actions D.1, "*Communicating awareness*" and D.2 "*Increasing awareness*", we proposed the following actions:

- Developing signals and panels. To ensure understanding and use of the qanat by the local community, the Council of the No-Ras should collaborate with the University of Tabriz to design information panels about the history of the qanat and its benefits for agriculture, livestock, drinking water and the sustainability of qanats, compared to modern water systems, such as dams or hydro-pumping machines. This type of activity is linked to the transversal ones in response to Action B.3 in group of activities 1.
- Organizing conferences and meetings. In addition to the visits to the qanat expected for meeting the requirements of Action C.4, the council of the No-Ras qanat will work together with the local university and the municipalities of Chavan and Tabriz to organize conferences and other public events. These types of activities will serve for communicating and raising awareness on the historical, cultural and environmental value as well as the economic benefits of the qanat.
- Creating webpages and other online tools. Over the last few decades, the use of social media and websites to communicate the importance of cultural and natural heritage has jumped to the top of the agendas of many institutions and projects [93,94]. These media are particularly effective for sharing content with children and teenagers, meaning future generations that will be in charge of the conservation, management and use of the qanat. Therefore, the Council of the No-Ras qanat should hire a social media and website developer and manager to create the No-Ras qanat website and social media accounts. These will also be relevant for advertising other activities connected to group of activities 4, such as conferences, events and visits to the qanat, as well as group of activities 3, such as training and job offers.

3.3.5. Group of Activities 5

The recommendations proposed for Group of activities 5, "*lack of understanding of the qanat as heritage*", match the Action criteria A.4, A.7 and D.3 of the ICOMOS-IFLA document (2017). Tailor-made activities were designed to meet the requests.

For Actions A.4, "*Inventory and catalogue rural landscapes at all scales*" and A.7 "*Promoting cooperation for research*", we proposed the following activity:

- Scientific research on the history of the qanat. Researchers from the local university will coordinate a historical analysis on the No-Ras qanat. This multidisciplinary activity encompasses a number of different approaches for reconstructing the development of the qanat and its landscape. These include the use of historical archival documents about territorial management (e.g., cadasters or military maps) [95–97], spaceborne and airborne historical and contemporary imagery of the area [36,98], archaeological and geoarchaeological survey (including palaeobotanic analysis) [99–101] and community-based documentation and mapping [102–104].

For Actions D.3, "*Supporting shared learning, training and research*", we propose the following activity:

- Interviews to collect oral history. This type of activity is tightly related to the above-mentioned approaches. It can enrich the quality and quantity of information collected for the historical analysis of the No-Ras qanat, as well as strengthening the sense of belonging towards the place by local people [105]. This type of research is generally conducted by university researchers targeting local communities (mostly elders) as well as members of the council of the No-Ras qanat and local farmers. These stories may be shared with the rest of the community through events, conferences as well as online tools (see Group of activities 4).

4. Discussion

In this section, we discuss the potential limits and problems of each activity proposed to meet the recommendations and mitigate the issues illustrated by Branduini et al. [36]. Moreover, we propose to read the changes proposed in the light of "morality of water management", introduced by Ertsen [20].

4.1. Potential Limits and Counteractions

For the first issue, "Mitigate water shortage", the assessment of costs and benefits of the current hydraulic infrastructures may result in the possibility of a balance or positive feedback between the two. In this case, the conservation and reuse of the No-Ras qanat envisaged in this paper will improve the current situation, acting as an additional source of water supply. The implementation, conservation and enhancement activities will instead require a substantial amount of funding. If the Iranian government or the local institutions are unable to support them with through ad hoc funding, one possible option would be to apply for specific funds from the Horizon Europe Clusters 2—Culture Creativity and Inclusive Society (for the heritage aspect), Cluster 5—Climate, Energy and Mobility (for climate related issues), Cluster 6—Food, Natural Resources, Agriculture and Environment (for food), many of which have yet to come out. These kinds of calls embrace wide topics and aggregate a large number of stakeholders. This solution also applies to the development of the water protocol, which would be part of the implementation phase.

As for "Mis-management and/or lack of documentation" (Issue 2), some members of the local community or other actors identified in this study may not be willing to join the council. Therefore, to consider the council sufficiently represented, it would be necessary to have at least a qanat council manager (mirab), the water clock operator (kayyal) and the accountant (hesabdar), together with one representative from the local farmers and the municipality of Chavan. Other figures from national bodies, such as MCHT, RWWTC and RAJO, may not directly be part of the council or covering operational roles, while it is essential for guaranteeing the council effectiveness to include members of the local community.

The activities related to "Loss of technical skills" (issue 3) may encounter the following types of problems: 1. lack of funding for organizing training and purchasing non-invasive sustainable technologies; 2. low participation of locals in training courses for moqannis and professional figures working in the qanat. In the first case, if the Iranian Government or local institutions are unable to provide funding for these activities, economic support can be sought in the Horizon Europe funds, in particular Clusters 2, 5 or 6 (see above). In addition to these lines of funds, the training can also be organized within the framework of capacity building projects, such as the EU-funded Erasmus+ Capacity Building KA1–3, involving not only local actors but also national bodies, private companies and universities. The second problem could be solved by extending the call for training also outside the borders of the region, thus, attracting people from other parts of the country.

As for issues 1 and 3, the activities related to issue 4 (lack of awareness) also present mainly potential economic problems. For example, economic support is crucial for developing signals and panels, creating webpages and other online tools, as well as for organizing conferences. For all these activities, we propose the same solution already identified in the cases of issues 1 and 3, to apply for the Clusters 2, 5 or 6 (see above) of the Horizon Europe programs.

In the event of low attendance at conferences and meetings, invitations can be extended to national and international guests in order to give greater prominence to this project. The same goes for visits to the qanat for children, families and schools. If local participation does not meet the expectations, schools and families from other regions of the country will be invited.

Problems related to the last issue may mostly arise due to the difficulties in conducting interviews for collecting oral history among the locals. One possible solution to solve the issue could be that of gathering only available stories from publications or the web.

4.2. Qanat as Moral Heritage

The solution proposed for the No-Ras qanat and the issues identified for its conservation and reuse also make it necessary to consider the relationship between the old infrastructure of the qanat and the people living in its premises, according to what the authors of [20] described as "moral landscape". The changes proposed are not neutral but will rather affect people that, in some cases, do not show direct personal or cultural connection with the qanats and their history. The social background may then divide the community between those looking at the project as something "bad" or "wrong" that will cause substantial damage, at least in the short term, and those who instead consider it "good" or "useful" and that it will enhance the area, reconnect the population to a partially forgotten past, also providing clean water in a sustainable way. Branduini et al., demonstrated that this dichotomy is partially due to the lack of awareness towards the history and benefits that this building may bring [36]. That is why Group of activities 4 and 5 are critical to allow the project to be fully understood by the entire community. In Ertsen's words, "*Relations need continuous confirmation, reconstruction and adaptation; maintaining stability is hard work for all human agents, precisely because other human agents and their non-human colleagues strike back*" [20].

5. Conclusions

In this article, we applied the guidelines from ICOMOS-IFLA on rural landscapes [33] to preserve, manage and reuse a historical hydraulic system, in particular, a water irrigation system, such as qanats and similar hydraulic structures, which are attested from the Mediterranean basin (e.g., Spain, Morocco, Italy, Libya, Egypt, Syria, etc.) to the Middle and Far East (e.g., Oman, Yemen, Iran, Armenia, Afghanistan and China), both in urban and rural areas. For each problem and recommendation that emerged in Branduini et al., several actions were also proposed based on the ICOMOS-IFLA guideline criteria [36].

In the discussion, we critically evaluated the potential problems affecting each activity proposed and provided possible solutions.

The testing of this methodology will allow for replication on any type of traditional rural landscape and it will:

1. Raise awareness among communities at any level on the preservation of their past and cultural origins, thus, meeting the requests of SDG 11.4.
2. Create a new sustainable economic resource passed down from the past to the present through interactive activities, thus, contributing to reach SDG 4 (lifelong learning).
3. To preserve and reuse an environmentally friendly system that could, at least partially, replace the existing polluting solutions (i.e., dam and other modern infrastructures). This last point is nowadays at the top of the agenda of numerous national and international institutions and it matches SDG 6 (Clean Water and Sanitation) and SDG13 (Climate action).

In the specific case of the No-Ras qanat, the current proposal should be ideally used by the RWWTC, RAJO and the municipality in collaboration with the other actors and beneficiaries identified to draft a masterplan encompassing the different groups of activities and hypothesizing costs and potential funding opportunities. This will bring multiple benefits both for the urban community of Chavan in terms of urban layout rationalization, increases in the economic value of buildings and other public and private assets, attraction of tourists visiting the qanat as well as researchers and farmers visiting the Centre for Organic farming in order to export its methodologies and approaches.

However, more than anything, our hope is that this project will have a positive impact on both the cities and citizens of Chavan and Tabriz in raising awareness on this important Iranian traditional heritage.

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Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest: The authors declare no conflict of interest.

Notes

1 https://ec.europa.eu/info/funding-tenders/find-funding/eu-funding-programmes/horizon-europe_en (accessed on 3 September 2022).

2 https://whc.unesco.org/en/list/?search=qanat&order=country (accessed on 3 September 2022).

3 https://www.fao.org/giahs/giahsaroundtheworld/designated-sites/asia-and-the-pacific/en/ (accessed on 3 September 2022).

4 https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl2-2022-heritage-01-04;callCode=null;freeTextSearchKeyword=traditional%20;matchWholeText=true;typeCodes=1,2,8;statusCodes=31094501,31094502,31094503;programmePeriod=null;programCcm2Id=null;programDivisionCode=null;focusAreaCode=null;destination=null;mission=null;geographicalZonesCode=null;programmeDivisionProspect=null;startDateLte=null;startDateGte=null;crossCuttingPriorityCode=null;cpvCode=null;performanceOfDelivery=null;sortQuery=sortStatus;orderBy=asc;onlyTenders=false;topicListKey=topicSearchTablePageState (accessed on 3 September 2022).

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Transition of Urban Morphology in the Mountainous Areas Since Early-Modern Times from the Perspective of Urban Historic Landscape—A GIS Tools and Historical Map Translation Approach

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Abstract: Regenerating cities must blend modernization and heritage. Both urban morphology and Historic Urban Landscape (HUL) highlight historical processes and may assist in regeneration. Using Chongqing as the study example may further understand mountain cities, which are prevalent worldwide but seldom examined in morphology research. This study explores and organizes the historical modernization of Chongqing's parent city from early-modern times to the present day using a universal approach established in this research developed by the HUL perspective and research framework, Geographic information system (GIS), Depthmap tool, and historical map translation method. Large-scale modernization occurred prior to the 1980s, followed by more modest rehabilitation projects. The whole procedure is described by the phrase "Construction first, then planning, then transformation," which entails a "free growth" block structure at the outset, along with planning control. The study contributes the following: (1) Establishing a theoretical framework and research technique for the universal city based on historical sources and modern instruments; (2) Chongqing's future sustainable development and historical preservation depend in large part on figuring out the city's complicated modernization history; (3) The study of mountain cities may benefit from understanding the geographical development and spatial dynamic layering of Chongqing. (4) This study bridges the gap in time by going beyond the early modern period covered by the previous ones and into the post-statehood era (1949–2022).

Keywords: urban morphology; spatial dynamic layering; GIS; historical map translation; sustainable development; historical preservation; mountain city

1. Introduction

Nearly all Chinese cities now have advanced from the stage of incremental development to the stage of stock regeneration [1]. The fundamental difficulty at this point is striking a balance between modernity and conventional urban patterns [2], and historic preservation is becoming a common element of urban planning and is seen as one of the major forces for revival [3]. Many scholars have studied urban change from the perspective of urban morphology [4–7], which emerged in the early 19th century, and three main schools of thought were formed: the Cozen historical–geographical school [4], the Muratori–Caniggia typological school [8], and the Versailles historic school [9]. All three viewpoints are based on old maps and materials, emphasizing the logic of urban composition [10], and advocate a historic evolutionary perspective to understand the city [11], despite the differences in their approaches. The Historic Urban Landscape (HUL) perspective and approach were verified to be an optimum ideology [12], which sees the city as the product of the interaction between the natural environment and human traditions accumulated over time [13], helping protect heritage areas in more sustainable ways [14]. On a theoretical level, two theories can serve as a guide for urban regeneration activity and sustainable development [15].

The historical process of urban modernization in China started around the late Qing Dynasty (the late 20th century) and is characterized as complex, dynamic, and non-uniform [16]. Sorting out the process is especially crucial during the period of urban regeneration [1]. Most of the materials that exist to record urban changes are historical documents and maps, which are essential to the historical study and reconstruction of the rural landscape [17]. Urban development now requires the use of cutting-edge research, technology, and tools to combine the database of historical urban geographic information [18].

The mountainous environment is widely spread in the world, where twenty-six percent of the world's population lives and covers twenty-five percent of the global land area [19]. Mountainous cities with undulating topography and complicated road networks offer an urban environment distinct from that of plain places [20]. There is some research on mountain cities that addresses spatial morphology and historical development, with the majority concentrating on ecology [21,22], geography [23], transportation [24], etc.

Chongqing, in southwest China, is a typical mountain city and has developed into a crucial hub city due to its advantageous position. Situated at the confluence of the Yangtze and Jialing rivers, Chongqing City has been an important town in eastern Sichuan since ancient times [25]. Most studies on Chongqing's cities concentrate on the macro and regional levels [26] and the technical elements of environmental ecology [27], with little research looking at meso and micro spatial patterns. Taking Chongqing as a study case can contribute to spatial morphology evolution research and the study of mountain cities.

This study aims to provide a historical-level theoretical foundation and research methodology for the universal city during the stock regeneration stage. With this aim, this paper creates an integrated city history map as a basis for historical research, and the city history map contains information over time, from the late 19 century to now, based on historical maps and documents [28]. Then, this paper establishes a set of urban historical transformation research approaches and frameworks from the perspective of HUL and urban morphology, using historical materials as research materials and cutting-edge technology to examine how urban morphology has changed through the case study of Chongqing.

Additionally, the majority of studies on this topic focus on the modern era (the late 20th century–1948). During this period, China has undergone a huge modern transformation. Modernization is complex, dynamic, and non-uniform and a hot topic in Sinology [16], so a large number of scholars have studied this period, and few focus on the post-statehood era (1949–2022). However, the time frame of this paper is from early-modern times to the present, bridging the gap in the study of Chongqing's urban morphology changes since 1949 in terms of time scale.

2. Materials and Methods

2.1. Historical Urban Landscape Perspective and Research Framework

A city's internal growth of its physical shape is the result of social, cultural, and other factors operating together, according to urban morphology, which emphasizes that the city is a combination of natural geography and artificial environment and that its development is a dynamic and continuous process [29–31]. Based on this, the intangible aspects of the urban landscape (which includes the natural and cultural as well as the physical and intangible) are given special consideration in the field of the urban historical landscape. Therefore, learning about the city from the perspective of the historic urban landscape is an essential first step.

The creation of a general- suitable framework (Figure 1) for the investigation of historic urban landscapes is attempted. Each urban component is interdependent on the others; thus, it is important to include the macro-regional, meso-city, and micro-block levels as part of the study context, and the linked contextual combination is the basis for conducting the study. It is, on the one hand, the physical of the city. Conzen's framework of townscape study begins with three aspects—pattern of plan, land use, and building forms—but the plan pattern is the most conservative morphological complex since it has remained relatively unchanged throughout the city's history. In order to study and explain the formation process of the plan pattern, a historical evolutionary perspective is used, and the elements of the plan are broken down into street and street-system, plots and street-block, and block-plan [29]. Street is the skeleton of the plan, its geometry and topological structure are the elements studied, and the street lines divide the street-blocks, each containing a series of property plots, the shape, and organization of which reflect the geographical variation. Block-plan refers to the area occupied by the building, and its shape and relationship to the plot are elements of the study (Figure 1). On the other hand, the perceptible space of the city highlights the subjective cognitive and perceptual side and can be studied through literature, images, and research materials from various time periods in order to analyze the public perception and supplement the daily life and invisible side of the city from an empirical vantage point [32,33].

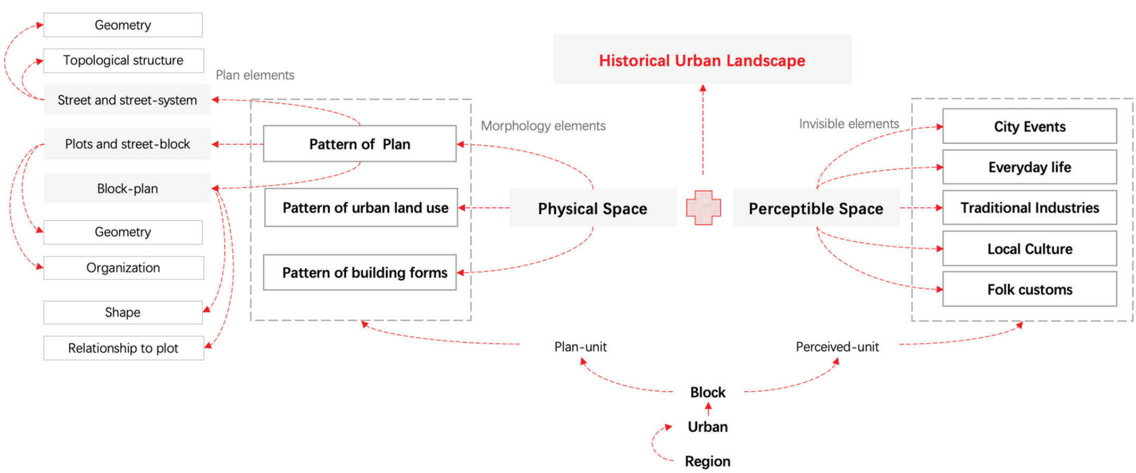


Figure 1. A general-suitable framework for the investigation. (Source: own study).

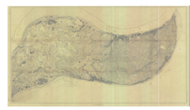
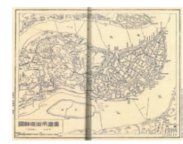
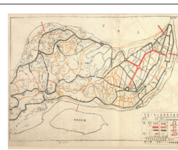
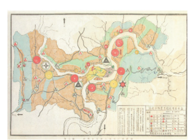
2.2. *Historical Map Translation Method and Integrated City History Maps*

For studies of urban evolution, particularly the city plan portion in the framework above, historical maps are a crucial source of information. City plans are a picture of the historical landscape's layers and are a goldmine of historical data.

This investigation spans the period between the late Qing Dynasty (the late 20th century) and the current day, and it includes maps of cities created before the formation of the People's Republic of China. Inaccuracies in cross-temporal spatial comparisons are inevitable due to the fact that the available historical maps were mostly created in a measured way, creating a gap between the precision of geographical position and the accuracy of contemporary maps. In order to visually portray the information of the current city on modern maps [28], it is important to utilize the historical map translation technique to convert the early historical maps into integrated history maps of the city using modern maps as the map foundation.

The four processes that make up the historical map translation method are the basic divisions. The selection of historical maps is the first stage. These historical maps may be categorized into three groups based on their use: mapping maps, thematic maps, and planning maps. Table 1 displays the ten typical maps that have been chosen. Most of the time, the other two types of maps are used as supplementary reference materials, but mapping maps, which contain rich geographical elements such as topography, water systems, and man-made features such as buildings and roads, are the most important materials for historical map translation work [34,35].

Table 1. Modern Historical Mapping, Thematic Maps and Planning Maps of Chongqing (Source: Historic maps, The historical atlas of Chongqing).

Name	**A Full Map of Chongqing's Geography**	**New Measurement of Chongqing City Full Map**	**Topographical Map of Chongqing**	**Chongqing Street Map**	**Chongqing City Street Detail Map**
Year	1900	1925	1929	1937	1945
Type	Mapping map	Mapping map	Mapping map	Mapping map	Mapping map
Information	Circumvallation, streets, street outlines, etc.	Circumvallation, streets, street outlines, etc.	Circumvallation, streets, street outlines, terrain	Circumvallation, streets, street outlines, road level	Circumvallation, streets, road level, etc.
Preview					
Name	Chongqing street map	Road network map	Land use map	Population distribution map	General traffic planning map
Year	1946	1946	1946	1946	1946
Type	Mapping map	Thematic map	Thematic map	Planning map	Planning map
Information	Circumvallation, streets, some block-plans, etc.	For road level research	For land use research	For population distribution research	For traffic planning research
Preview					

The second step is extracting, filtering, and classifying map information's constituent parts. The informational components on the historical map must first be removed. Because of the urban morphology and traffic network involved in this research, the retrieved components must be inspected and categorized. However, certain thematic maps may also give information on population distribution and land use, and it excels at obtaining aspects of quantitative categories such as perimeter and side lengths.

The third step is using Arcgis to align, locate, and overlay the fixed components as the reference coordinate system. The study components are placed and overlaid on the maps using the fixed elements as spatial reference coordinates, and the historical maps are aligned with the contemporary satellite maps using Arcgis. A basic direction in terms of area, time, and information should be present throughout the translation process. Translating the main streets, waterways, and other elements based on the city gates and walls is a good example of setting the big spatial pattern before refining others; translating maps not drawn with modern technology is a good example of restoring maps closer to the present time first [28].

Using the 1940s Yuzhong District map as an example, fixed elements were identified from a modern satellite map and used as control points; existing city gates and landmarks were then used as precise reference coordinates; these eight coordinates (Table 2) were comprised of the locations of the four city gates (Dongshui, Taiping, Renhe, and Tongyuan) and four landmarks (Jiaochangkou, Monument to the people's Liberation Xiaoshizi, and Bashu Secondary School). The current satellite image of Chongqing City from Google Earth and the 1946 Chongqing City Street Map were imported into Arcgis. Using the "Geographic Alignment" toolbar and the current satellite map as the base map, the eight control points on the 1946 Chongqing City Street Map and the current satellite map were clicked one by one until they were aligned. The information on the same historical stage is then translated into this map (Figure 2).

Table 2. Eight precise reference coordinates (Source: Google Earth).

Reference Coordinate	Dongshui Gate	Taiping Gate	Renhe Gate	Tongyuan Gate	Jiaochangkou	Monument to the People's Liberation	Xiaoshizi	Bashu Secondary School
Longitude	106.594311	106.589156	106.586298	106.573766	106.58056	106.583541	106.589954	106.568528
Latitude	29.565065	29.558876	29.556701	29.561748	29.558926	29.563475	29.566232	29.568175

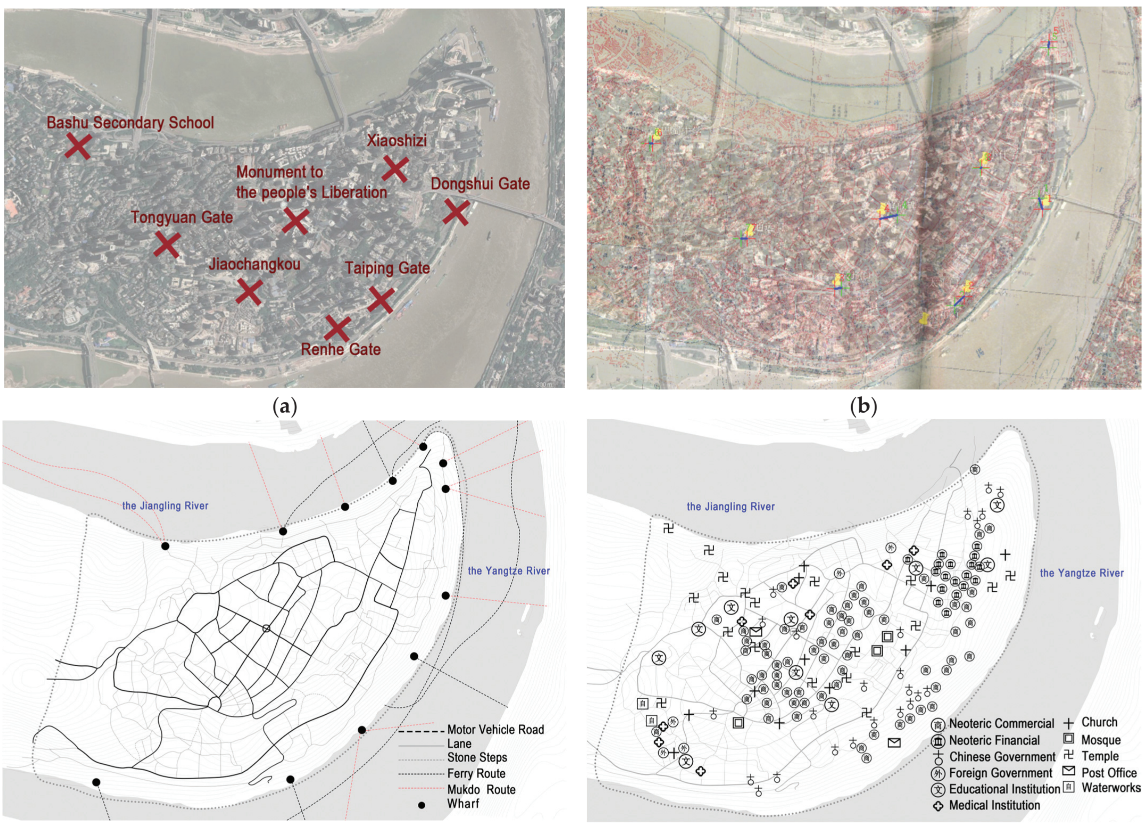


Figure 2. (**a**) Reference coordinate in Google Earth satellite map; (**b**) Geographic alignment in Arcgis; (**c**)Translated map-Transportation situation in the 1940s; (**d**)Translated map-Important buildings distribution situation in the 1940s. (Source: Arcgis Screenshot, historical maps).

In the final step, errors are corrected using documentary sources. There is a need for further geographical correction of the spatial information retrieved from the historical map, and this correction is mostly based on textual information [28]; the majority of this textual information is sourced from local records and other authentic historical sources. It takes time to translate historical maps, and the newly created urban historical maps must be continually improved.

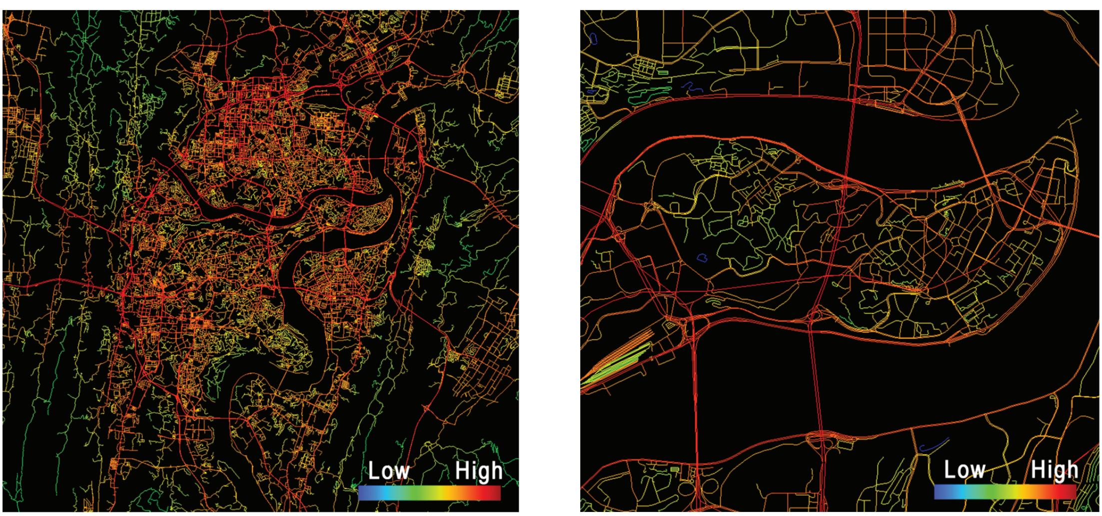
2.3. Gis and Depthmapx Tool

In general studies of historic urban landscapes, qualitative descriptions are used to draw conclusions. However, urban landscape research using only qualitative methods, to an extent, is not convincing, and scientific research must be used to summarize the development of things from quantitative data. Qualitative methods are used to describe the city at a macro level, while quantitative methods are typically employed at a more micro level, such as street length and width shape, street frontage height, building density, volume ratio, etc. [36,37].

Urban spatial quantitative indicators may be broken down into many different types, including those that are morphological, dense, functional, etc. [38]. Quantitative index systems may be useful research tools and methods, but they need to be tailored to the specific aims and goals of each study. Focusing on urban transportation networks and plan spatial morphology, this analysis breaks down urban morphology into geometric, topological, and functional indexes, which are then applied to the two subsets of urban morphology, lines, and surfaces [39].

GIS can analyze geometric parameters, which are used to describe the geometric form of the material, such as the perimeter, average height, shape index, number, density, etc. of buildings, or the length, width, and density of roads, sidewalks, bike lanes, and other types of infrastructure. ArcGIS is used to collect geospatial information from the internet, process it, and display the results graphically [40–42].

The DepthmapX tool can analyze topological structure (Figure 3), which ignores the particular physical spatial scale and emphasizes the structural relationship of space, such as the degree of integration and choice in the spatial syntax; functional parameters are used to express the land use and functional distribution, which can express the spatial vitality at the level of social activities and complement the singularity of the aforementioned material scale [43,44]. They consist of functional density, functional mixture, and the kind of land parcels.



(a) (b)

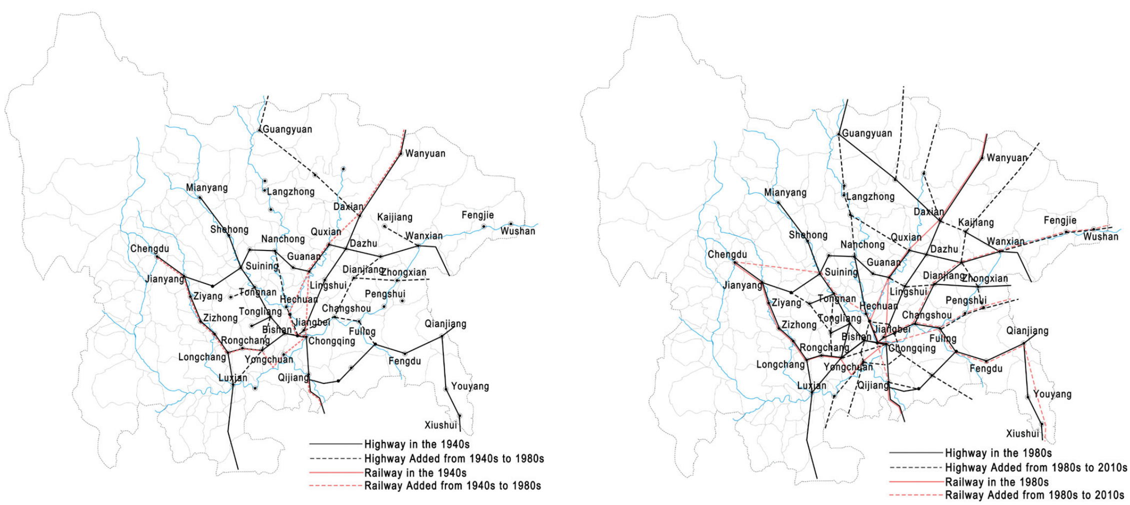
Figure 3. (**a**) Integration of Chongqing's main city; (**b**) Integration of Chongqing's parent city. Chongqing's parent city refers to the Yuzhong Peninsula, a region with a long history as a political, cultural, and economic center. (Source: DepthmapX Screenshot).

The variability of the research materials should be taken into consideration while conducting ephemeral investigations. Since the research materials are based on current maps, it is challenging to obtain both functional class parameters and density-related indicators in geometric parameters in the early-modern literature. Many data were unavailable before the development of contemporary scientific and technological methodologies.

3. Overview of the Built-Up Area of Chongqing's Main City's Spatial Changes

3.1. High-Speed Traffic and Increased Road Density

The movement of people and things that require transport between and within the cities of Chongqing has risen more often as a result of modernization and urbanization, which is a sign of increasing mobility [45,46]. A city cannot grow in size without its dynamic component, which is traffic [47]. Since early-modern times, the transportation system—which is the carrier of material flow—has seen drastic changes in terms of transportation technology, methods, and network. After the liberation, the waterway-based transportation situation from the early stages of the country's founding was gradually changed, and after strengthening the construction of highways and railroads, the connection between Chongqing and the neighboring cities was gradually tightened (Figure 4), all in keeping with the general trend of the evolution of the city's external transportation.



(**a**) (**b**)

Figure 4. (**a**) The evolution of transportation between Chongqing and the surrounding cities from 1940s to1980s; (**b**) The evolution of transportation between Chongqing and the surrounding cities from 1980s to 2010s; (Source: Historical maps, Chongqingshizhi, Google Earth, etc.).

Urban traffic has risen in volume as a result of modernity, population growth, economic development, and the concentration of a large number of people and cars inside the city, while urban sprawl has increased the distances people must travel to go anywhere in the city. Changes in intra-city transportation modes and technologies have resulted from rising intra-city mobility, while the intra-city transportation network system has evolved to meet the demands of urbanization in terms of land use, traffic, and other factors [48]. The expansion of new urban paths that new modes of transportation rely on, such as the construction of high-capacity, quick, and efficient railways and elevated railways to address the issue of high hills and steep slopes in Chongqing (Table 3), can be summed up as the first change in the urban transportation network. The second change is the continuous widening of inner-city roads and the growing density of the population. The complexity of the transportation system has increased as a result of the diversity of traffic; therefore, the organization of urban transportation is more three-dimensional and systematic [49].

Table 3. Development of subway in Chongqing (Source: the National Bureau of Statistics, Chongqing Shizhongquzhi).

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Passenger volume	2.002×10^7	3.347×10^7	3.988×10^7	4.181×10^7	4.576×10^7	8.332×10^7	2.4363×10^8
Operating mileage/km	17	17	17	19	17	70	131
Number of vehicles	52	60	60	84	108	296	558
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Passenger volume	4.0049×10^8	5.1710×10^8	6.3247×10^8	6.9343×10^8	7.4310×10^8	8.5787×10^8	1.04187×10^9
Operating mileage/km	170	202	202	213	264	313	329
Number of vehicles	702	888	918	978	1176	1806	2130

Because of its location at the confluence of two major rivers, Chongqing has always relied heavily on the transportation services provided by its ports. After the start of the War, ferries emerged in response to the resulting population boom. Before the 1960s, traveling from one side of the city to the other required using the waterways that crisscrossed it; however, after the construction of bridges over the rivers and cableways to the two rivers, faster and more convenient ways of crossing the rivers emerged, displacing the cross-river routes and, later, the more heavily trafficked downriver routes [50]. The new transportation methods changed the way people traveled around the city, and public water transportation gradually declined (Figure 5).

3.2. Spatial Expansion and Functional Area Transformation

The built-up area of Chongqing's main city has recently shown a tendency for outward growth (Figure 6). Specifically, the data on Chongqing city's outward expansion were slow from 1956 to 1983, which was related to the overall national background of the time, and the growth rate accelerated from 1983 to 1997, which was the expansion of the urban spatial pattern brought about by the accelerated economic development of Chongqing city since the reform and opening up, and the built-up area grew rapidly from 1997 to 2007 (Table 4), and Chongqing as a municipality directly under the Central Government grew rapidly as a result [51]. Chongqing's development focused on the main city at first, and the city expanded to non-main urban areas in the later years, a manifestation of urbanization in the rural areas; this expansion continued in the years 2007–2017, but at a slower rate than in the decade before the direct administration. The city expanded to the west and south in its early years, but after the administration, with better land and greater urban development space reserves, the north became the major direction of urban growth.

Table 4. Change in the built-up area of Chongqing's main city (Source: Chongqing shizhi and the National Bureau of Statistics).

Year	**Built-up Area of Chongqing's Main City/km^2**	**Proportion of Built-up to the Main City**	**Built-up Area of Chongqing/km^2**	**The Built-up Area Proportion of the Main City to the City**
1952	44.36	15.07%		
1983	84.14	15.10%		
1997	156.20	2.85%	389.8	40.07%
2007	489.90	8.95%	873	56.12%
2017	732.20	13.38%	1573	46.54%

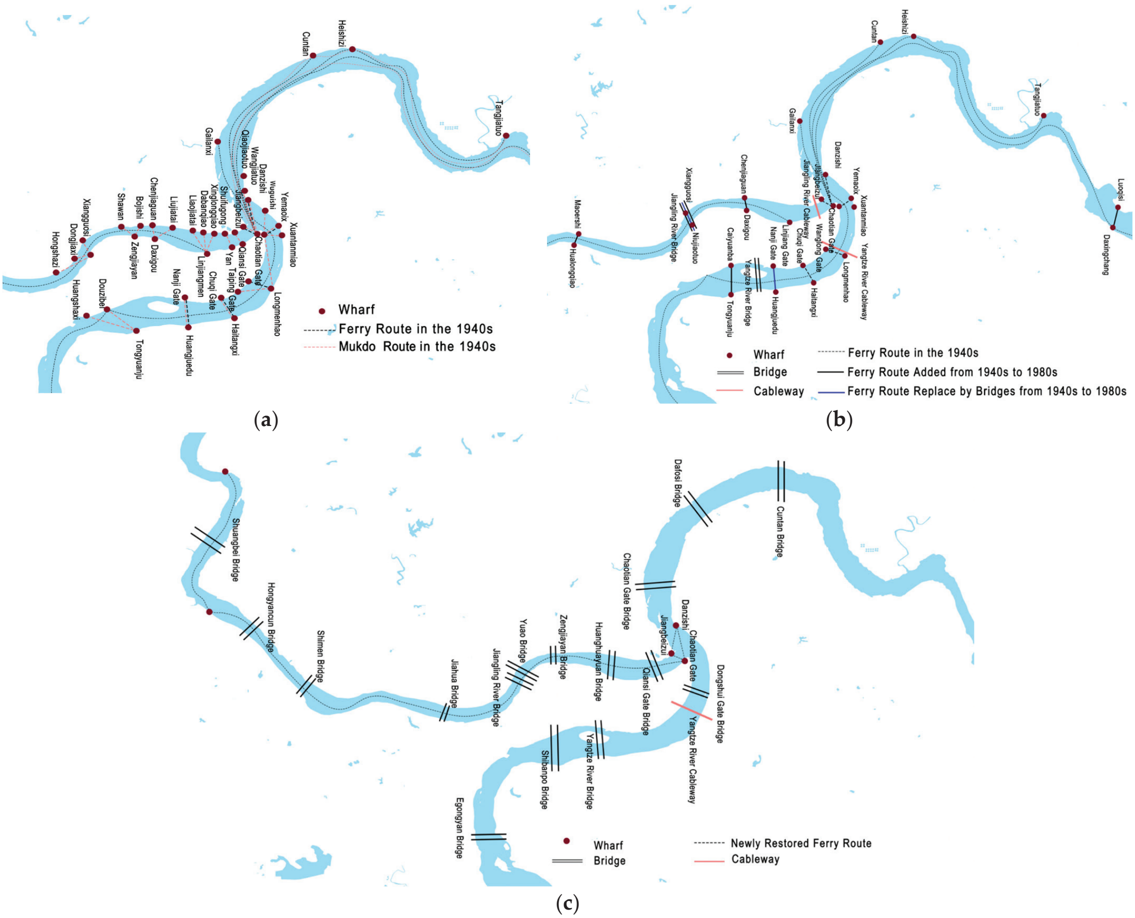


Figure 5. (**a**) Mukdo Routes and Ferry Routes on the Two Rivers in the Early 1940s; (**b**) Changes in the way the main city crossed the River from the 1940s to 1980s; (**c**) The contemporary way to cross the River; (Source: Own study).

As the city grew, the macroscopic land use arrangement changed, which in turn impacted the nature of urban life to some degree. Given the city's geography and traffic patterns before 1949, the city's industrial property was virtually evenly spread on the riverbank terraces. The vast majority of the inwardly relocated factories were constructed with only the water transportation conditions of the Jialing and Yangtze rivers in mind, without a thorough understanding of the conditions in Chongqing, with intertwined factory areas and residential areas, an extremely irrational layout, and an extremely uneven production distribution, with factories, monstrously concentrated on the banks of the river. New industrial zones formed on the south side of the city as the city's scientific progress led to the gradual evacuation of industrial land initially clustered on both sides of the Jialing and Yangtze rivers with an exceedingly inappropriate layout. Since the 1990s, the government has actively promoted and supported large-scale industrial development in order to achieve development goals. This has directly led to the priority growth of industrial land, and it is clear that the new periphery of the city is primarily an industrial zone. The city's infrastructure is progressively becoming more streamlined.

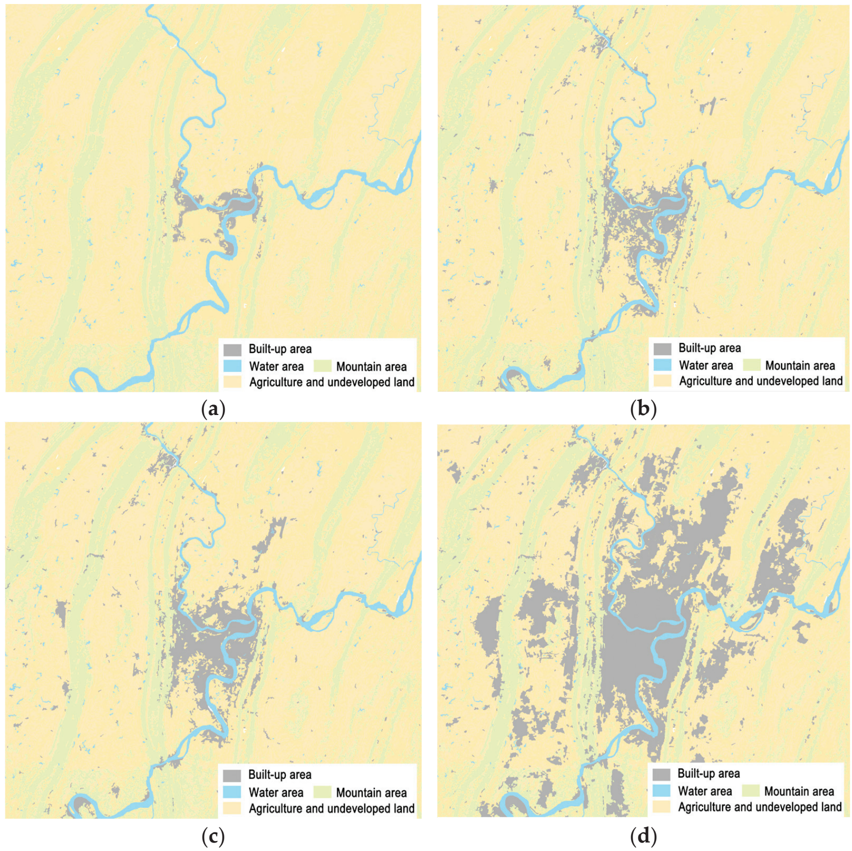


Figure 6. (**a**) The built-up area of Chongqing's main city in the 1940s; (**b**) The built-up area of Chongqing's main city in the 1980s; (**c**) The built-up area of Chongqing's main city in the 2000s; (**d**) The built-up area of Chongqing's main city in the 2010s; (Source: Resources and environment science data center of Chinese Academy of Sciences).

4. Identifying the Spatial "Dynamic Layering" of Chongqing's Parent City

4.1. Modernization of the Transportation Network in the Parent City

Chongqing's ancient Yuzhong Peninsula serves as a case study for this investigation of the city's evolution. Located in the heart of Chongqing city, which has served as a geographic and developmental epicenter at different times since antiquity, the Yuzhong Peninsula is bounded by the Yangtze River to the east and south and the Jialing River to the north. The sample of this investigation is drawn from an area bounded on the west by the Yangtze River Bridge, Shihuang Tunnel, and the Huahuayuan Bridge, and on the east by the Jialing River and the Yangtze River itself. This sample, covering an area of roughly 3.2 square kilometers, represents the oldest and densest part of Chongqing's urban landscape, and the process of change in this region since early-modern times is sorted out so that Chongqing's urban historical landscape may be studied in detail.

More than 240 alleyways and lanes, none wider than eight feet, existed in Chongqing in the early 1920s (Figure 7), and there was not a single road in or around the parent city. Less than 40 km of drivable roads existed in 1949; by the end of the 1980s, that number had increased to 72.84 km (Figure 7), and the overall length, road grade, and construction quality of drivable roads had all been improved [52,53]. With the construction of new roads such as the Jialing River Binjiang Road and the Yangtze River Binjiang Road, the road network plan pattern of the river section has been altered, and the existing roads such as Minquan Road, Zhongxing Road, and Heping Road have been widened and repaired to become the city's main arteries. Furthermore, the Qiansimen Tunnel, Shihuang Tunnel, and Jiefangbei Underground Ring Road were built to alleviate ground pressure and demonstrate the tunnel's reasonableness as a mode of transportation in the mountain city of Chongqing [54], which is of great significance to the development of urban roads (Figure 7).

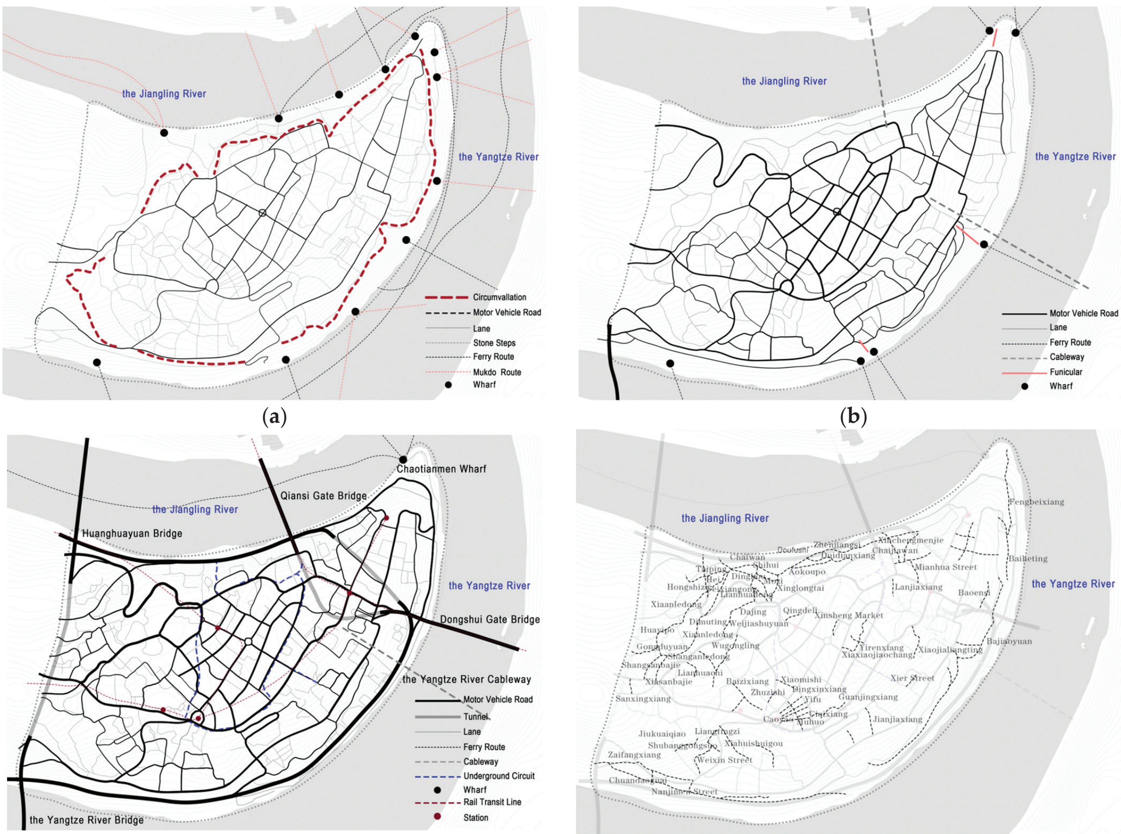
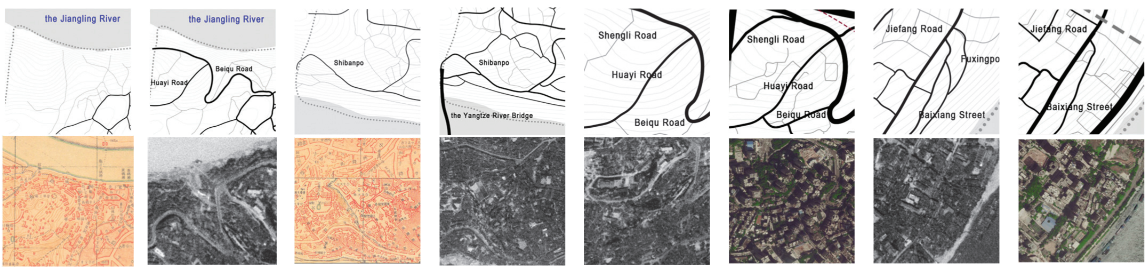


Figure 7. (**a**) Transportation network in the 1940s; (**b**) Transportation network in the 1980s; (**c**) Transportation network in the 2010s; (**d**) Eliminated lanes from the early-modern times to now. (Source: Historical maps, Chongqingshizhi, Google Earth, etc.).

After reform and opening up, the city sped up the pace of municipal construction, the existing street lane for extensive renovation and reconstruction, upgrading the quality of the road surface. This was a major change from the 1980s when the ladder lane was built to connect the upper and lower halves of the main city to supplement pedestrian access to the road. Because of the original streets' and lanes' low widths, some were combined and restored, while others were eliminated entirely. First, the junction of Binjiang Road and four bridges; second, the nodes of Jiefangbei, the nodes of the Changchangkou, and the nodes of Chaotianmen; and third, the nodes of North District Road and Kui Xing Lou [49,55].

Focusing on the variations in road texture patterns within the sample. The first is the changing of geometric characteristics of the traffic network (Figure 8), including the number, breadth, density of roads, etc. Arcgis provides access to the relevant data and imagery for this section. As the number of roads rises in density, it follows that more roads are being built. At the beginning of the nation, the road density of passable vehicles in the sample was 6.24 km/per km^2 until the 1980s, when the road density of passable cars in the sample was 8.31 km/km^2. The width of the three major roadways has risen dramatically, with the center arterial road increasing from the original 7 m to 32 m, the southern arterial road widening from 7 m to 33 m, and the northern arterial road widening from 10 m to 30 m [49–51], city streets are now three to five times as wide as they were back then. Technology advancement has made it possible to circumvent limits on urban road building. The construction of trunk roads along the river expanded the road space outward to the river, such as the Jialing River Binjiang Road with the rise in intra-city traffic [52,53], certain roadways were enlarged and built (Figure 8).



(**a**) (**b**) (**c**) (**d**) (**e**) (**f**) (**g**) (**h**)

Figure 8. (**a**,**b**) Partial north main road change between the 1940s and the 1980s; (**c**,**d**) Partial south main road change between the 1940s and the 1980s; (**e**,**f**) Partial north main road change between the 1980s and the 2010s; (**g**,**h**) Partial south main road change between the 1980s and the 2010s. (Source: Open Street Map, Chongqing Street map, U.S. Geological Survey, Google Earth).

After that comes the information on integration, choice, connectivity, etc., all of which vary depending on the spatial topological structure. Depthmapx may be used to derive this information (Figure 9). Integration measures how easy it is to access both a single axis and the whole system as a whole [44]. It shows how well one street connects to others and how well one street blends into its surroundings. The results of the Depthmapx calculation clearly show that places closer to Jiefangbei have better traffic, a higher degree of integration, and a greater concentration of social and cultural life than those near rivers. As the contour line along the river is thick, and early road development is hampered by the city wall, the integration degree is low; this is connected to the " Fixation" [29] and the natural topography. The frequency with which people cross a street is a measure of the "transit traffic" in a given metropolitan area and may be inferred from the degree of its choice. If there is a lot of choice on the street, it means plenty of people walk there every day. Along the route, you can observe how the planned riverside road development would improve the flow of local traffic.

The parent city's transportation system is a dense grid created by zigzag roadways along the contour lines, which is a reflection of the layered character of the city's historical environment [56], which has developed mostly organically as a result of historical development. First, the transportation infrastructure has developed by increasing the traffic link to the city. Second, there has been an ongoing improvement to the parent city's internal traffic system, which has resulted in a traffic organization that spans all three dimensions. Roads in the parent city were scarce and displayed tree-shaped and radial structures during the early-modern era; they were features peculiar to the ancient city center, but they eventually gave way to irregular dense grid-like patterns when highways were improved. Thirdly, the micro-level road morphology of the parent city is characterized by a rise in both the width and density of roads, as well as an increase in the quality of integration and accessibility of the road network and the openness of the street network.

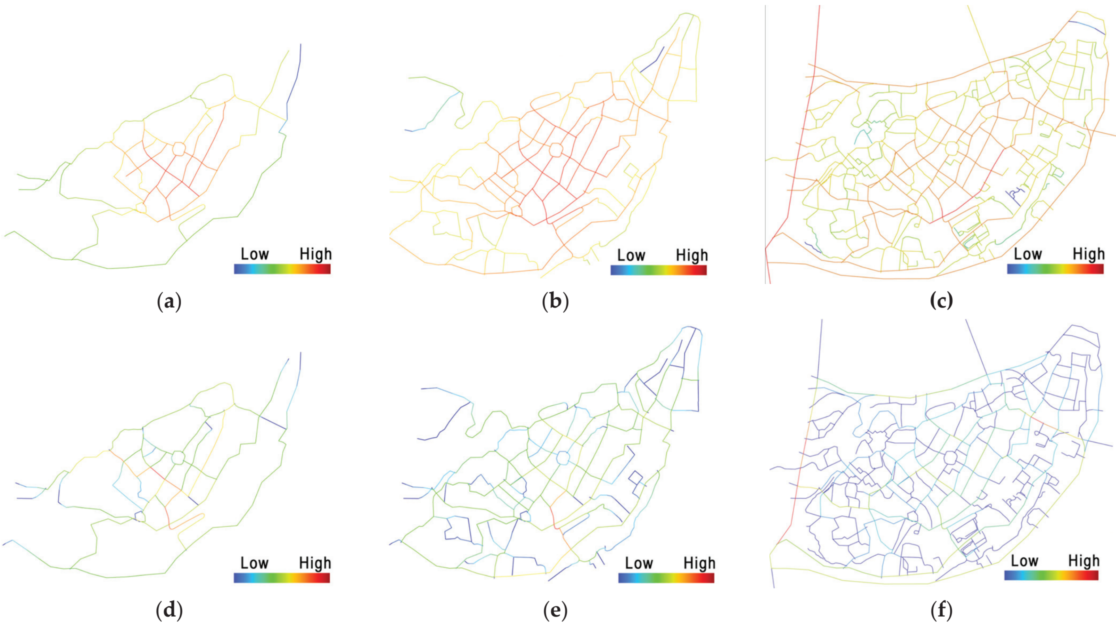


Figure 9. (**a**–**c**) Integration in the 1940s,1980s and 2010s; (**d**–**f**) Choice in the 1940s,1980s and 2010s. (Source: Depthmapx screenshot).

4.2. Transformation of Functional Space and Plan-unit

From the historic maps of functional space transformation (Figure 10), since 1949, the parent city's functions have modernized and become more complex, and the internal function structure has been constantly adjusted to rationalize and develop into the tertiary industry, which now accounts for more than 90% of the output value in Yuzhong District. Specifically, the city's administrative functions have been weakened due to two factors: first, the commercial functions have taken the form of aggregation and have been developing into tertiary industries; and second, the administrative institutions that were originally gathered on Linsen Road in the lower half of the city have been relocated to Shangqing Temple. The residential function was strengthened to accommodate the increasing population, and commercial spaces were clustered around Chaotianmen, Jiefangbei, and Bichangkou [53]. The number of commercial trade form units increased, and the appearance of commercial form units became more modern [49,54,55].

According to the geometry of plan-units, the Mother City's block contours eventually changed from being rough to having tiny grid-like block contours, giving rise to the present dense network of small block contours (Figure 11). The phenomena of block profile redivision have occurred, and the tendency of "networking" has become more pronounced. The number of block contours inside the main block profile has increased, and the size of the block profile has been shrinking. "Construction first, then planning, then transformation" construction first "free growth" block shape, mixed with planning control, describes the whole process [56,57].

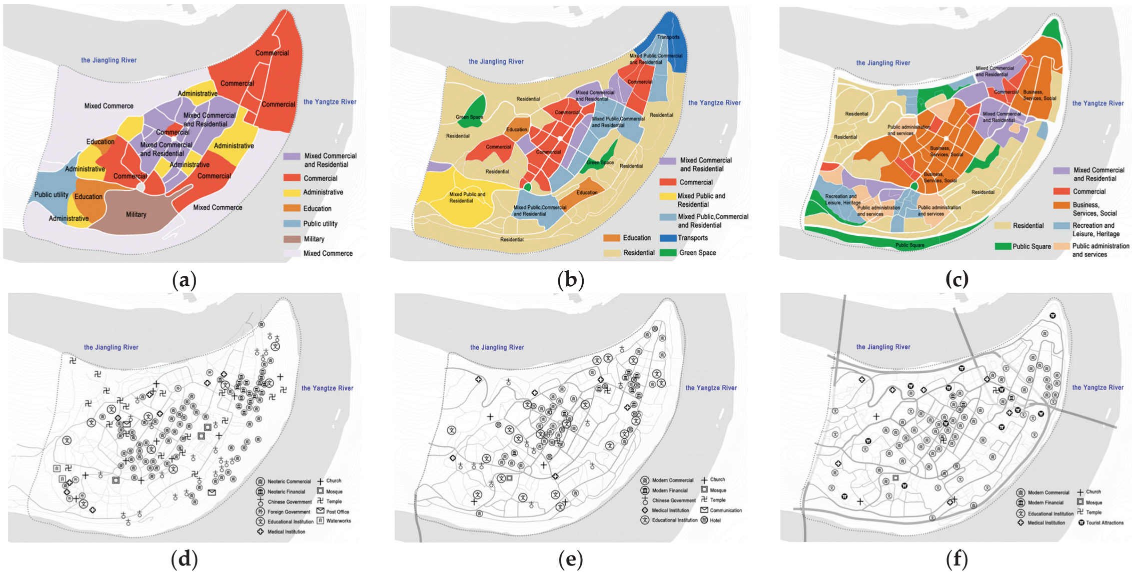


Figure 10. (**a**–**c**) Functional Space in the 1940s,1980s and 2010s; (**d**–**f**) Important buildings in the 1940s,1980s and 2010s. (Source: Historical maps, Chongqingshizhi, Google Earth and etc.).

The study of the turnover of components within plan-unit has been hampered by the absence of particular topographical and architectural drawings from the 1980s. In recent years, the facts and literature reveal that the turnover rate of architecture in the parent city has been more than 90% [58–60]. At the same time, the average height of buildings in the city has increased significantly, reaching roughly 4–5 stories by the end of the 1980s [47,48]. This is by far the most noticeable alteration to the period's interior space. The average height of a modern building is 33.8 m (roughly 10 stories), and the presence of numerous high-rise buildings has transformed Yuzhong District into a densely populated region characterized by its abundance of skyscrapers (the building plot ratio in this sample is 5.83, while the overall plot ratio is 3.29). These current data are derived from GIS.

Because of its dense population and rapid growth, the parent city has been redeveloped after its independence with Chinese emphasis on restoring its historic core. Therefore, there has been a process of inheritance and succession in the make-up of the plan-unit internally. Due to the stability of the street element and the fact that large-scale streets have stayed mostly unchanged since they were established, with the exception of expansion and reconstruction, the phenomena of succession can be seen in the block of plan-unit. Most of the internal structure of the plan-unit was inherited from the previous stage of slow development when small-scale progressive regeneration was the focus, and the later stage entered the large-scale regeneration stage, to modern commercial and commercial morphological units and modern residential morphological units. Early on in the large-scale renovation, most structures were demolished since their design was no longer compatible with the city's ongoing evolution.

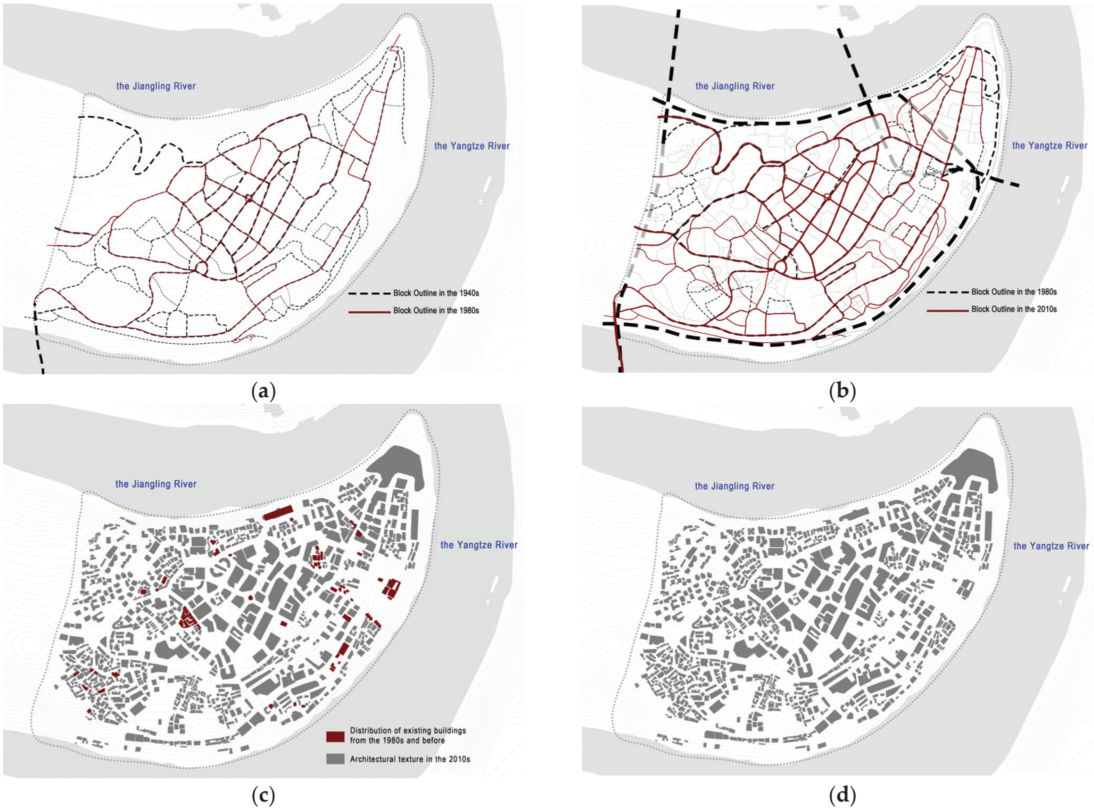


Figure 11. (**a**) Block Distribution of the parent city in the 1940s and 1980s; (**b**) Block Distribution of the parent city in the 1980s and 2010s; (**c**) Transportation network in the 2010s; (**d**) Eliminated lanes from the early-modern times to now. (Source: Historical maps, Chongqingshizhi, Google Earth and etc.).

4.3. The Parent City of Chongqing in Experience and Perception

In the aforementioned study, historical maps and documents are used as primary sources to examine the historical change process of the visible portion of the historic urban landscape utilizing tools and techniques such as the spatial syntax approach, ArcGIS, and the historical map translation method. The historic urban landscape also has a perceptible component, which is often the intangible component and includes urban activities, folk traditions, and local culture. The written and visual works that document the city's evolving face may shed light on the metropolis from a new angle. Chongqing's river and boats, as well as the city's meandering alleyways and alleys, are chosen in this paper as representative cultural aspects of the river and mountain city [61].

Chongqing's expansion and development coincided with the city's location between two rivers; water transport was crucial to the city's growth and prosperity throughout the Republican period (Figure 12). It used to be that ships coming up the Yangtze from the lower sections of the river would moor on the other bank of the city, necessitating the use of ferries to travel to the city itself. Chongqing's river, docks, and boats are cultural icons that should be preserved as part of ongoing attempts to revitalize the city's historic core.

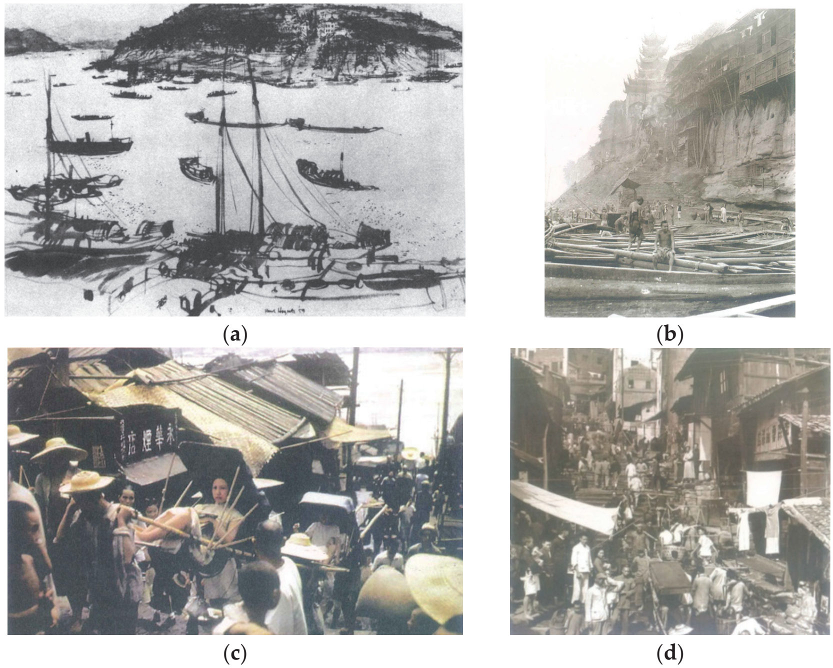


Figure 12. (**a**) Sketch of looking north of the river from Jialing wharf in the early-modern times; (**b**)Dongshui Gate in the 1920s; (**c**) Sedan chairs in Chongqing; (**d**) Stairways of Chongqing in the 1940s. (Source: Sketch by Paul Hogarth, photograph by Sidney David Gamble, William.l.Dibble and H.Allen.larsen, Life magazine).

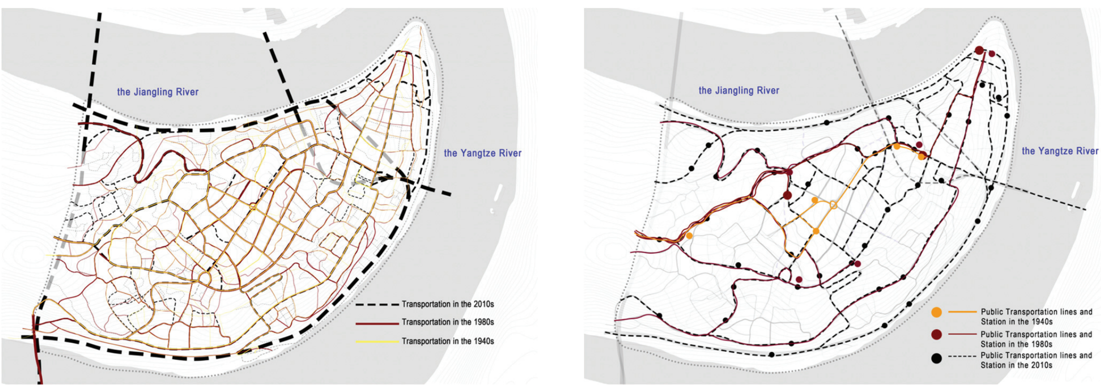
Chongqing is built on a hilly, undulating landscape; therefore, the city's winding, tiny mountain streets, and alleys, as well as the stairways linking various heights, are distinctive characteristics. Since ancient times, the mountain city's twisting alleys and lanes have not only provided a means of transportation but have also served to interpret the personality and qualities of the area. Chongqing's unique hilly environment necessitated the adaptation of a unique mode of transportation: the sedan chair (Figure 12). Sedan chairs were often seen on the city's stone stairways. Many old streets and alleys remain today, preserving the city's unique memories from before the 1980s when urban construction was hurried forward, and the low modern hammock houses were replaced by modern high-rise houses, and after the liberation when houses could no longer be renovated due to technical and economic constraints. Urban reconstruction efforts should not destroy or drastically alter the look of ancient streets and alleyways.

5. Conclusions and Prospects

In the past 40 years, a standardized construction mode has been universally adopted in Chinese historic urban areas as the most efficient urban planning strategy [62]. Urban regeneration is a comprehensive and integrated practice [63], and historical and traditional spaces must be adapted to modern needs, preserving historical character and regenerating these areas for adaptation to the changes ahead [64]. The tension between modern society and traditional space in China is apparent, as well as traditional to modern. The urban form bears the marks of the transition from rural to urban [65]. Urban change gradually threatens the historic areas of the city [66], and urban heritage preservation depends on the understanding of the historical evolution.

According to the methodology and framework of urban morphology, several researchers have studied the morphological changes in Guangzhou and come to the following conclusions: the city has become denser and more functionally diverse internally [57]; the morphological units show a general characteristic of inheritance and succession; the overall structure of street space is more stable throughout the process [39], and the evolution of urban spatial form is closely related to local political, economic and cultural factors [67].

The most intuitive outcome of this research is the creation of a historical map of Chongqing using a modern map as the base map. This historical map contains information on various stages of the city's history, features the overlapping of information from multiple periods, and allows for easy comparison. Three distinct eras of contemporary Chongqing's parent city are shown in Figure 13, each with its distinct street layout and network of public transit lines, illustrating the city's sequential and evolutionary development (Figure 13). After laying the groundwork with qualitative research, the next step is to integrate quantitative methods with technological tools to compute the development of geometric, structural, and functional factors and present the results in a scientifically rigorous manner. For all other cities, this work has some ramifications.



(**a**) (**b**)

Figure 13. (**a**) The transportation network in three distinct eras; (**b**) The public transportation network and station in three distinct eras. (Source: Historical maps, Chongqingshizhi, Google Earth and etc.).

The contributions and innovations of this paper: firstly, the integration of a universally suitable framework and methodology based on the use of HUL and urban morphology frameworks in conjunction with the actual situation in China. Using the parent city of Chongqing as a case to develop the interpretation, dividing the urban historical landscape into a visible part and a perceptible part, the visible part being the part based on urban morphology, exploring the planar pattern and spatial form. The perceptible part combines social activities, urban imagery, and daily life [68]. Secondly, the historical materials are analyzed by GIS and Depthmap technical tools, combining qualitative and quantitative research methods to provide new ideas for the empirical study of space. Thirdly, the study presents a technique for the investigation of spatial change in mountainous cities through the use of historical maps as a source and the spatial shaping traits of three-dimensional mountainous cities.

The study has certain limitations. The scale and precision of the research are somewhat lacking due to the absence of historical data that have prohibited the restoration of the early urban building fabric, for example, in the Guangzhou Urban Study [57], and the discussion is mainly focused on the plan, and there is a lack of discussion on land use and function. These could be used as guidelines for future research, on the one hand, to dig deeper into the historical materials and, with the help of sophisticated tools, perhaps archaeological methods, to deduce more accurate historical maps of the city, and, on the other hand, to carry out research on the internal characteristics of urban spatial form, such as function and land use, and to consider public participation, government policies and other aspects [69], to improve and revise the existing framework and methods.

In China, large-scale demolition and construction have been common and standard in the past 40 years, and some practices have demolished the heritage and reconstructed the imitation in historic urban areas, such as "Antique Streets" or "European Streets" [62]. Some projects constructed many odd-shaped buildings and broke the historical relationship among the historic landscape [70]. These practices failed to balance conservation and development due to a lack of understanding about historic preservation.

The findings of this study may be used to preserve historic areas and serve as guides or strategies for urban planning and regeneration. Firstly, it can be used as a foundation for cultural heritage conservation, as cities with historical heritage have an advantage in the global market [71]; the findings of this study can be used to determine a location's historical spatial pattern and preserve the original pattern as much as possible [72]. The findings of this study also offer a foundation and a plan for urban planning and urban administration from the perspective of the historic urban landscape.

According to this study, some urban planning strategies can be suggested. To ensure the sustainability of the planning process, the planning horizon can be divided into three levels: point, line, and surface. At the point level, which refers to buildings and plots (Figure 1), the historical and memorial buildings should be preserved entirely [73], such as the monument to the People's Liberation, the Chongqing people's auditorium, and other landmarks. Some larger historic buildings, such as the Luohan Temple, Qing Dynasty Ba County Government Offices, and people's park, should be preserved and given new uses [73] for attractions, leisure, and other function to ensure the rebirth of historical heritage [74]. At the line level, referring to streets and street-system (Figure 1), main historic roads and rivers should be focused on, linking historic buildings and integrating them into some lined landscape that included parks and was able to accommodate a range of activities to help citizens integrate and accept the new roles [74]. For instance, Chongqing's two rivers and the wharf space have long served as a symbol of the city's collective memory, and consider reactivating the ferry routes and holding regular festivals. Moreover, the south main road, which linked Chaotianmen Wharf, Huguang guild hall, People's Park, Dongshui Gate, Nanji Gate, and other historic buildings (Figure 7a), was lined with shops of all kinds, gathering merchants from all over the world, and was also the seat of the early government in the 1920s. It should be highlighted for its historical character through regular closure of the road during important festivals to hold large fairs and trading events. At the surface level, referring to historic blocks, Chongqing's parent city could be divided into some different blocks, such as the Chaotian Gate block, Jiefangbei block, Nanji Gate block, etc.; each of them has different historical memory and characters, which should be considered as the main feature of the block. Such as the Chuqi Gate block, in ancient times, there was a folk rhyme that "Chuqi Gate, the herb house, cures all kinds of diseases", and it was still the most important market for Chinese herbal medicine since the 1920s, with many of the country's most famous old pharmacies having warehouses and shops here. In this block, Chinese herbal medicine culture could be highlighted by transforming some historic buildings into Chinese medicine halls and Chinese medicine markets. Moreover, during the regeneration process, based on the city history map from this research, the relationship between property rights, space, and resident behavior to understand the evolution of Chinese urban historic areas and internal motivation.

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Article

Research on the Spatial–Temporal Distribution and Morphological Characteristics of Ancient Settlements in the Luzhong Region of China

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Abstract: This paper focuses on ancient settlements in the Luzhong region (the centre of Shandong Province) of China and analyses the spatial–temporal distribution and morphological characteristics of ancient settlements with the help of GIS technology and the perspectives of archaeology and cultural geography. Specifically, the 1972 settlements collected were used to establish a database of settlement site attributes. Then, the DEM data were superimposed with the settlement sites, and calculations of the kernel density, elevation, slope, aspect, and buffer zone were further carried out. The distribution and characteristics were refined based on quantitative and qualitative analyses. The study found that the Neolithic period, the Shang–Zhou period, and the Qin–Northern and Southern Dynasties were the three high points of settlement development. In these three periods, the centres of the large-scale distribution of settlements experienced changes from a "single centre" to a "continuous belt" to a "double centre'. In general, the spatial and temporal characteristics of the settlement distribution were continuously developed through time, while the spatial characteristics show that the main body continued to change locally. In different periods, settlements tended to be in the alluvial plains located between 20 and 60 m and with a slope of less than 6°. At the same time, they showed the obvious characteristic of living close to water. The past, present, and future are in the same chain of time; meanwhile, these settlements are the predecessors of today's cities, towns, and villages. So, this study provides a basis for protecting their heritage value and provides a reference for the coordination of human–land relations, which can help achieve global sustainable development.

Keywords: ancient settlements; urban heritage; spatial–temporal distribution; morphological characteristics

1. Introduction

Settlements are a concrete manifestation of human occupation of the earth's surface and are an important part of the formation of the surface's form. At the same time, ancient settlements are places where ancient humans lived and carried out their production and social activities; they contain the rich material and spiritual connotations of human developmental history and are a valuable cultural heritage and spiritual treasure for contemporary times. Their temporal and spatial distribution was influenced by environmental, cultural, and political factors with different characteristics. The past, present, and future are in the same chain of time. The study of the spatial and temporal distribution and morphological characteristics of settlements can, therefore, provide a basis for the conservation of their heritage value, as well as be a reference for the reconciliation of human–land relations, thus contributing to global sustainable development.

The spatial distribution of settlements has been a subject of interest for a long time in a number of disciplines, including archaeology, geography, and architecture. Geographic Information Systems (GIS) have been applied to archaeological research since the 1980s. With the further development of GIS technology, there have been many successful examples of the application of GIS to settlement archaeological research, and the theory is gradually becoming mature [1]. In recent years, numerous scholars have carried out studies on the Yangtze River basin [2], the Minjiang River basin [3], the Dalian region [4], the Ili River valley [5], and other regions within China. However, relatively few similar studies have been carried out in the lower reaches of the Yellow River Basin. Shandong, located on the lower reaches of the Yellow River, is one of the important birthplaces of Chinese civilisation, and archaeological work has shown that its cultural genealogy is well established. In chronological order, it includes: Yiyuan Man (about 400 ka B.P.), Xintai Wuzhutai Homo Sapiens (about 50–20 ka B.P.), the fine stone tool remains of the Yishu and Wensi river basins (about 10 ka B.P.), the early Neolithic culture (about 8.4–7.7 ka B.P.), the Beixin culture (7.3–6.1 ka B.P.), the Dawenkou culture (6.1–4.6 ka B.P.), the Longshan culture (4.6–4.0 ka B.P.), the Yueshi culture (4.0–3.6 ka B.P.), and all subsequent historical periods. Each of these periods are closely linked, and the cultural traditions have evolved in the same way [6]. Within Shandong province, the Luzhong region (the centre of Shandong Province) is a relatively independent climatic, geographical, and cultural unit. Moreover, the political, economic, and cultural centre of Shandong has been located within this area since Linzi of Qi in the Spring and Autumn period. The Luzhong region is, therefore, a valuable case for studying the spatial and temporal distribution and characteristics of settlements at the core of Chinese civilisation. It can also enrich the case of settlement studies in the lower Yellow River Basin.

2. Materials and Methods

The spatial extent of this study, the Luzhong region, specifically includes Jinan (except Jiyang District and Shanghe County), Zibo (except Huantai County and Gaoqing County), Tai'an, and Weifang (Figure 1). The climate in the Luzhong region is temperate monsoonal, with a more pronounced continental character. It is cold and dry in winter, and hot and rainy in summer. The average annual temperature is 12 °C–14 °C, and the annual precipitation is approximately 680–860 m [7]. As can be seen from the map, the region has the Taiyi Mountains in the centre, which are surrounded by hilly undulations that transition into flat plains. In terms of water systems, the Yellow River flows through the territory. In addition, there are dense small- and medium-sized rivers, which have also developed their own water systems. This study covers the period from the Neolithic period to the Qing dynasty and is divided into six time periods according to cultural sequences: Neolithic, Shang and Zhou, Qin to Northern and Southern Dynasties, Sui to Five Dynasties, Song and Yuan, and Ming and Qing.

Based on the temporal and spatial scope of the study, a total of 1972 settlements were selected from the State Administration of Cultural Heritage [8] and the National Cultural Heritage Administration [9] by using "ancient city", "old city", "settlement site", "fortified cities", "fortresses", "castle", and "mountain city" as keywords. These data include all levels of cultural relic protection units and historic cities, towns, and villages. Thus, the data selected balanced representativeness and breadth, and they are able to reflect the spatial and temporal distribution characteristics and evolution patterns of settlements in the central Shandong region. In addition, the Digital Elevation Model (DEM) of the Luzhong region required for the research was derived from the GDEMV3 30 M resolution digital elevation data from the Geospatial Data Cloud website.

This paper analyses the spatial–temporal distribution and morphological characteristics of ancient settlements in the central Shandong region based on data from 1972 settlements and with the aid of a GIS system. Specifically, first, the 1972 data collected were divided into 6 stages according to cultural sequences (Neolithic, Shang and Zhou periods, Qin to North and South Dynasties, Sui to Five Dynasties, Song and Yuan Dynasties, Ming and Qing Dynasties) to establish a database of settlement attributes and perform kernel density calculations. Then, in the QGIS 3.22 software environment, the DEM map of the Luzhong area was overlaid with the settlement points to carry out the calculation of the elevation, slope, aspect, and buffer zone. At the same time, the spatial and temporal distribution characteristics of the settlements are comprehensively explored in relation to the historical context and dominant cultural forms in which the settlements were located. Based on the above quantitative and qualitative analyses, the distribution and evolutionary characteristics of the settlements are derived.

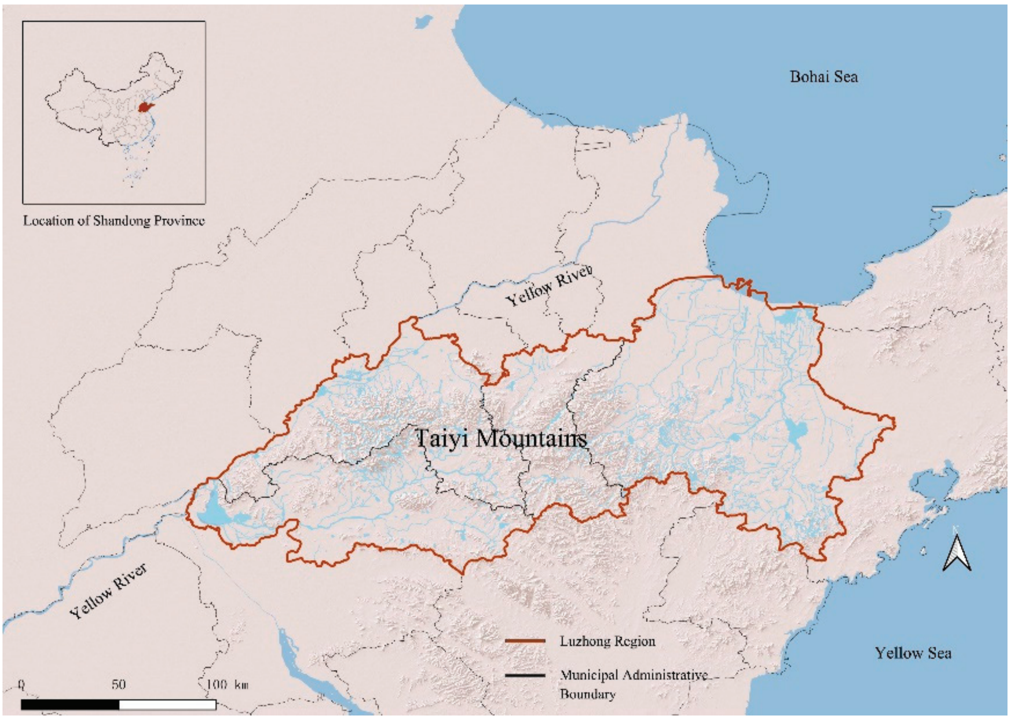

Figure 1. Location and scope of the Luzhong region.

3. Results

3.1. Spatial and Temporal Distribution of Settlements

The database of ancient settlements in the Luzhong region, which was established by using GIS, directly reflects the distribution of settlements in each period. This helps to visualise the distribution pattern and spatial–temporal evolution of the ancient settlements in the Luzhong region in the timeline and facilitates the logical analysis and quantitative expression of the spatial–temporal evolution of the ancient settlements.

There have been human activities in the Luzhong area since the Stone Age, and a large number of settlements were built in the Neolithic period, with 638 Neolithic settlements in the Ancient Settlements Database for the Luzhong area. The Shang and Zhou Dynasties were the period with the most intensive construction activities in the region, with the number of settlements reaching 681. This was followed by a slight decline in the "Qin to Northern and Southern Dynasties" period, but the number of settlements remained high at 591. By this time, the settlement construction activities in the Luzhong region reached their peak, and the settlement system was constructed. Thereafter, there was only sporadic construction on this basis in the following three periods of "Sui to Five Dynasties', "Song and Yuan Dynasties', and "Ming and Qing Dynasties" (Table 1).

Table 1. Number and visualisation of ancient settlements in each period.

Period	The Neolithic Age	Shang–Zhou	Qin–Northern and Southern Dynasties
Number of settlements	638	681	591
Visualisation based on GIS			
Period	**Sui–Five Dynasties**	**Song–Yuan**	**Ming–Qing**
Number of settlements	30	25	7
Visualisation based on GIS			

The Neolithic, Shang and Zhou Dynasties, and Qin to Northern and Southern Dynasties, where settlement construction activities were intensive, were selected for further kernel density calculations of their settlement distributions. The higher the kernel density value, the darker the colour, indicating the existence of large-scale concentrated settlement distribution in the area [10]. In the kernel density analysis, during the first construction peak, the Neolithic Age, the density of the settlement distribution in western Weifang increased significantly (Figure 2), covering eastern and northern Qingzhou, southwestern Shouguang, and northern Changle. The settlements in the region were mainly distributed in the middle reaches of the Mi River, the upper reaches of the Dan River, the Yang River basin, and on the diluvial platforms between rivers.

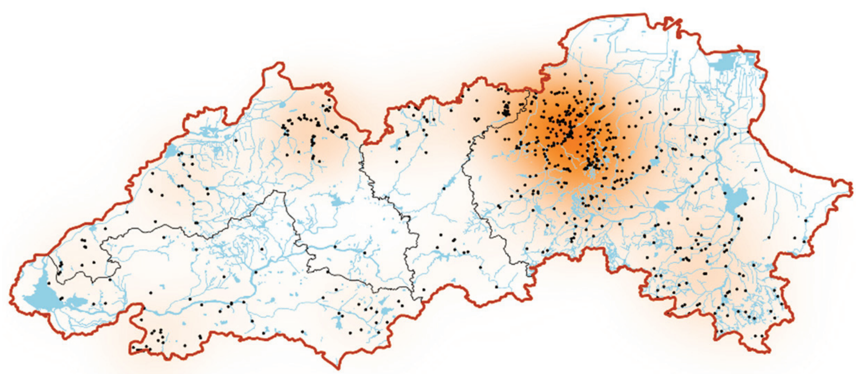

Figure 2. Kernel density of ancient settlements in the Neolithic Luzhong region.

The Shang–Zhou period was the second peak of construction. The density of the settlement distribution in the northern foothills of the Taiyi Mountains increased significantly during this period (Figure 3), forming a continuous state in western Weifang, northern Zibo, and eastern Jinan. Settlements were mainly distributed in river basins, such as those of the Mi River and the Xiaofu River, as well as in the diluvial platforms and alluvial plains between rivers. Meanwhile, there was a slight increase in density in the southwestern part of the Luzhong region.

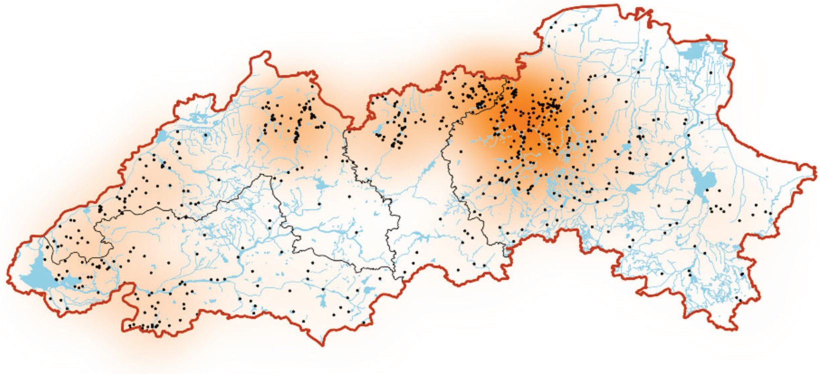

Figure 3. Kernel density of ancient settlements in the Luzhong region during the Shang and Zhou Dynasties.

The last peak of construction was during the "Qin–Northern and Southern Dynasties" period, and the distribution of settlements in the Luzhong region was characterised by a double centre (Figure 4). The first centre was located in the western part of Weifang and in the northeast of Zibo, covering Zhoucun, Linzi, and Qingzhou, with settlements mainly in the Xiaofu River Basin, the middle reaches of the Mi River, and the upper reaches of the Dan River, as well as in the flooded terraces and alluvial plains between rivers. The second centre was located in the southeast of Weifang, in the Zhucheng area, and the settlements were mainly distributed in the Wei River Basin.

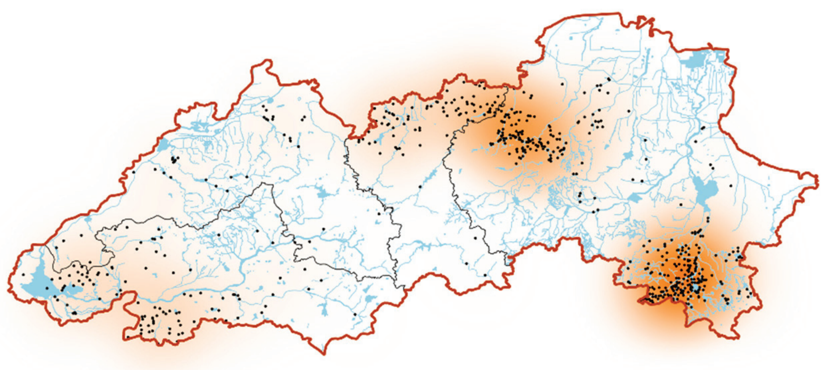

Figure 4. Kernel density of ancient settlements in the Luzhong region during the "Qin–Northern and Southern Dynasties" period.

3.2. Settlement Distribution in Relation to the Natural Environment

In the development of the settlement, it was first and foremost closely linked to the natural geographical environment. It cannot be separated from the favourable conditions provided by the environment, but is also subject to various restrictions imposed by it. Therefore, this section uses GIS to perform elevation, slope, aspect, and buffer zone calculations to explore the distribution characteristics and evolutionary features of settlements.

The DEM data were overlaid with settlement points to produce maps of the settlement's elevation, slope, aspect, and buffer zone distribution (Figures 5–8). Based on the elevation calculation and statistics, it shows that neolithic settlements were mainly distributed below 200 m above sea level, and 71.3% of the settlements were located between 0–100 m (Figure 5, Table 2). There were only scattered settlements in other elevation intervals. During the Shang and Zhou periods, settlements were still mainly distributed below 200 m above sea level, but the altitude range of distribution was expanded, and the number of settlements distributed in higher-altitude areas increased significantly, even reaching up to 868 m. During the period of "Qin to Northern and Southern Dynasties', the distribution of settlements contracted to lower altitudes and was mainly concentrated in the 0–100 m altitude range, with the number of settlements in this range reaching 83.6%.

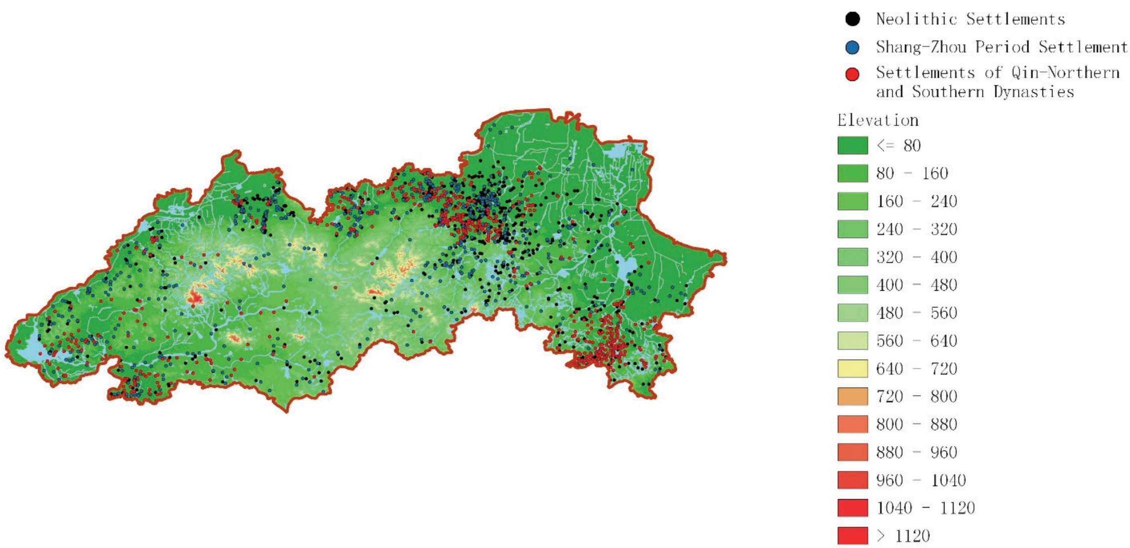

Figure 5. Elevation distribution of settlements in different periods.

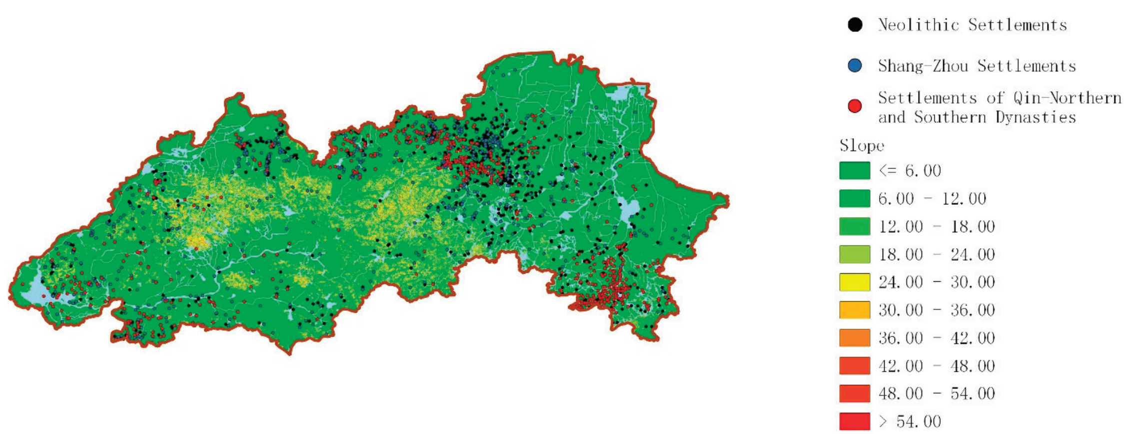

Figure 6. Slope distribution of settlements in different periods.

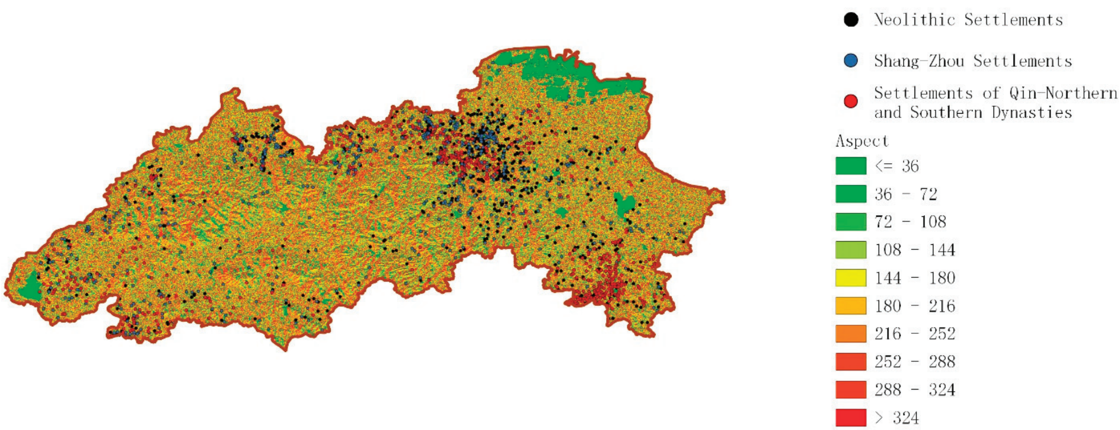

Figure 7. Aspect distribution of settlements in different periods.

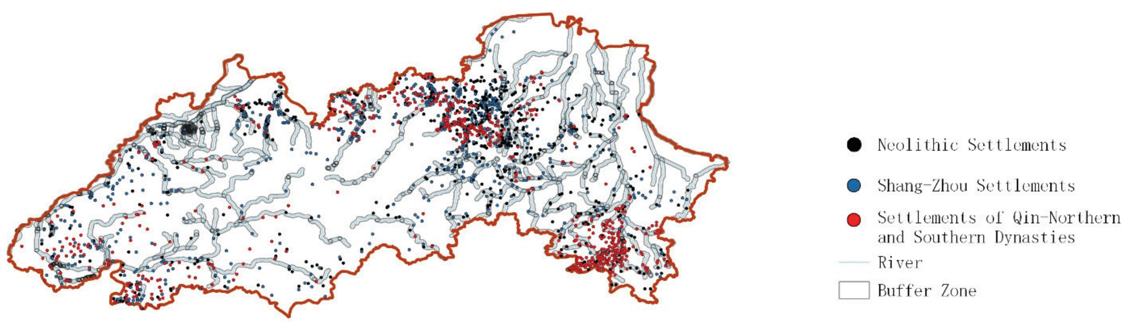

Figure 8. Relationship between settlement distribution and buffer zones in different periods.

Table 2. Elevation distribution of settlements in different periods.

Elevation	0–100	101–200	201–300	301–400	401–500	>500
Neolithic Period	446	148	24	7	4	0
Shang-Zhou	475	151	27	15	8	5
Qin-Northern and Southern Dynasties	494	87	8	2	0	0

The slope and aspect refer to the spatial orientation and inclination of the local surface slope. The magnitude of the slope directly affects the scale and intensity of surface material flow and energy conversion. The greater the slope, the greater the likelihood of mudslides and landslides [11]. In the statistics and analysis of the slope, this study uses the following grading: a slope less than 3 degrees is very suitable for human habitation, a slope from 3°–6° is relatively suitable for human habitation, and a slope from 6°–10° is not well suitable for human habitation (Table 3). The study found that the number of settlements in the "very suitable" and "relatively suitable" zones was high, with the sum of the two zones accounting for 63.2%, 61.9%, and 58% of the total number of settlements in the three periods. At the same time, there are a considerable number of settlements in the "not well suited" zone in each period, while the number of settlements in the "unsuitable" zone is relatively small. The aspect is one of the important factors that determine the local reception of sunlight and redistribution of solar radiation on the surface of the earth, directly causing local differences in climate characteristics [11]. In the calculation of the slope's direction, the value is taken as 0–360°, with due north as 0 and increasing clockwise. The study defined 90°–270° as good and quite good light, 45°–90° and 270°–315° as comparatively bad light, and 315°–360° and 0–45° as bad light. According to the distribution and statistics of settlements on the slope direction in different periods (Figure 7, Table 4), it is found that settlements are mainly distributed in the 90°–270° interval with good and quite good light, and the percentage of the number of settlements in this interval in each period is 48.4%, 49.3%, and 49.7%. The proportion of data remains stable and shows a slight upward trend. The number of settlements distributed in other intervals is low, with 23.7%, 23.4%, and 21.7% of settlements distributed in the comparatively bad interval in different periods, while 27.9%, 27.3%, and 28.6% of settlements were distributed in the bad interval in three periods.

Table 3. Slope distribution of settlements in different periods.

Classification and Slope Interval	Very Suitable for Human Habitation <3°	Relatively Suitable 3°–6°	Not Well Suited 6°–10°	Unsuitable >10°
Neolithic Period	162	241	149	86
Shang–Zhou	165	257	157	102
Qin–Northern and Southern Dynasties	140	203	162	86

Table 4. Aspect distribution of settlements in different periods.

Classification	Good, Quite Good	Comparatively Bad		Bad	
Aspect Interval	90°–270°	45°–90°	270°–315°	0–45°	315°–360°
Neolithic Period	309	81	70	75	103
Shang–Zhou	336	72	87	78	108
Qin–Northern and Southern Dynasties	294	63	65	85	84

As rivers were the lifeline for early human survival and development, the relationship between settlements and rivers also needs to be fully considered. Through the calculation and statistics of the buffer zone (Figure 8, Table 5), there were 313, 311, and 309 settlements distributed within the 1000 m buffer zone of rivers in the Neolithic, Shang and Zhou, and Qin to Northern and Southern Dynasties periods, respectively. This number would be further increased if the tributaries of the river were included in the statistics.

Table 5. Number of settlements distributed in the buffer zone in different periods.

Time Stages	Neolithic Period	Shang-Zhou	Qin-Northern and Southern Dynasties
Number of settlements in the buffer zone (1000 m)	313	311	309

3.3. Settlement Distribution Dominated by Different Elements

In the process of settlement development, the dominant elements gradually became complicated. This section explores the distribution characteristics and evolutionary features of settlements by combining the distribution of settlements with the historical background and dominant cultural forms in which the settlements were located.

According to the above analysis, the Neolithic settlements were distributed in large numbers in the eastern part of the Taiyi Mountains. Specifically, they were concentrated in the flooded terraces and alluvial plains at the northeastern end of the mountains, forming a distinct centre. The formation of the monocentre was mainly influenced by both the geographic environment and the climate. The flooded terraces and alluvial plains in the western part of Weifang were flat and suitable for cultivation, and the higher terrain was protected from flooding, so the natural environment showed strong stability. Thus, it became an ideal place for ancient people to flourish and accumulate a large number of settlements. Other areas had fewer settlements due to their different environmental and climatic conditions. For example, the western part of the Luzhong region is low-lying and has little space for detouring compared with other regions. As for the environment and climate in that period, on one hand, the climate was warm and humid, with abundant precipitation and high river flows; on the other hand, the relatively high sea level caused a lowering of the specific drop of rivers entering the sea and an increase in water levels [12]. The dual influence of the climate and sea level caused the low-lying areas to be waterlogged, and flooding disasters were frequent. Therefore, these areas were not suitable for human survival, and the number of settlements was small.

The analysis of the settlements in the Shang and Zhou period shows that the main distribution of settlements in the Luzhong area was concentrated at the northern foot of the Taiyi Mountains, west to Zhangqiu, and east to the Neolithic centre. On the basis of the centre of the Neolithic settlements, a continuous belt was formed. In addition, a large number of settlements were also concentrated in the southwestern part of the Luzhong region. The reasons affecting the distribution of settlements at this stage were not only physical geography, but also economic geography and geopolitical structure. After 5 ka. B.P., the climate became less warm and humid, but remained relatively mild until 4 ka BP. The frequency of arboreal pollen decreased while that of pollen for the drought-tolerant plants such as Artemisia and Chenopodiaceae increased in northwestern Shandong. In addition, no remains of Chinese alligator have been discovered in the sites during the late Dawenkou—Longshan cultural stage. It showed that the climate had a cooling and drying trend [12]. This trend became even more prominent around 4 ka BP. This was clearly recorded in the sediments of the northwestern Shandong Plain [13], the central Shandong Province [14], and the Yishu River Basin [15]. After 3.5 ka BP, the climate fluctuated slightly, but generally stabilised with a mild and dry character. The evolutionary trends in the paleoclimate of the Shandong region are consistent with those of China's paleoclimate [16], but differ in specific years due to geographical characteristics. In the western plains, due to the lowering of the sea level and the drying of the climate, the natural environment of the low-lying areas, which was previously unsuitable for human existence, improved, and these areas were gradually exploited on a large scale. In addition, the development of the east–west avenue that formed at the northern foot of the Taiyi Mountains [17] likewise promoted the development of settlements. Meanwhile, with the retreat of the sea, the distribution of settlements rapidly advanced northward. The elevation analysis of the settlement distribution also shows that the lowest elevation of the settlement distribution is below 1 m, or even close to 0 m. The large number of settlements distributed at the western end of the Taiyi Mountains was mainly influenced by the geopolitical structure on the basis of its geographical conditions. This area was the closest to the central area of the Shang Dynasty, so the distribution of settlements was quite dense [18].

From the Qin Dynasties to the Northern and Southern Dynasties, two centres of settlement distribution were formed at the northern foot of the mountain range and in the Zhucheng area. Compared with the previous period, the continuity and changes were equally obvious. The continuity was that the settlement distribution centre at the northern foot of the mountain range continued. The first thing that changed was a reduction in the concentrated distribution in the northern foothills of the mountain range; settlements in the west decreased compared to the previous period. More importantly, there was a new centre in Zhucheng. The formation of the new centre was influenced by various factors, such as the natural environment, humanities, and politics. During the Shang and Zhou Dynasties, Zhucheng was located at the border of two countries for a long time; in the Spring and Autumn period, the northern part belonged to Qi and the southern part to Lu; in the Warring States period, after Chu destroyed Lu, most of Zhucheng belonged to Qi [19]. The location of the border and the frequent wars restricted the development of regional settlements. According to historical documents, in 219 BCE, the First Emperor of Qin 'moved 30,000 households under the Terrace' [20]. If each household had only three people, there would be nearly 100,000 people. The population growth brought about rapid local development, and the number of settlements rose, forming a distinct centre.

4. Discussion

From the above analysis, we can see that there was human activity in the Luzhong area in the Stone Age, and a large number of settlement construction activities began in the Neolithic period. The Neolithic period, the Shang and Zhou period, and the Qin to Northern and Southern Dynasties period were the three high points of the development of settlements. In these three periods, the centres of the large-scale distribution of settlements changed from a “single centre” to a “continuous belt” to a “double centre”. By the time of the “Qin to Northern and Southern Dynasties” period, the settlement system in the Luzhong region had been formed, and the cities, towns, and villages of today were basically developed on this basis. At the same time, under the construction policy of “strong trunk and weak branches” of the central government, the construction of habitats in Shandong began to be reduced [18]. Since then, most of the existing settlements were inherited and only sporadically built. From the perspective of the whole country, the interactions between the settlements in the Luzhong region and the surrounding areas grew from a strong position in the early days [6], gradually developing into the country system [18], and becoming one of the most important components of Chinese civilisation. The ancient settlements in the Luzhong region showed continuous development over time, and spatially, they show the characteristics of a main body continuing local changes.

Based on the calculation and statistics concerning the elevation, slope, aspect, and buffer zone, it was found that most of the settlements in different periods were located below 100 m in elevation (Figure 9), and based on further detailed analysis of the 0–100 altitude interval, the settlements were mainly concentrated in the 20–60 m interval. With the retreat of the sea and improvements in technology, the settlement distribution expanded to the sea, on the one hand, and the lowest elevation of the site distribution in the Shang and Zhou periods reached 1 m or even approached 0 m. On the other hand, the distribution also expanded to higher elevations. Human settlements also appeared at elevations of 700–900 m in the Shang and Zhou periods. On the whole, the distribution of settlements was gradually reduced by the limitations on altitude, and the distribution gradually spread more widely. In terms of slope, settlement sites tended to be chosen in flat areas with slopes of less than 6°, and more than 50% of the settlements in all periods were located in such zones (Figure 10). The flat areas allow for easy access to travel, water, and agricultural production. The fact that the number of settlements in the 3°–6° slope interval is greater than in the flattest interval should be the result of a combination of factors, such as distance from water sources, slope direction, altitude, etc. Although ancient people preferred to live on flat terrain, some still chose to survive on sloping areas in order to survive because of the limited resources available on flat terrain. In contrast, settlements are still found in areas with slopes $\geq$10° or even >20°, which should be related to military or defensive functions. In terms of the aspect, the number of settlements located in the good and quite good light intervals was significantly higher than that in the bad and comparatively bad intervals in all three periods (Figure 11). It is therefore inferred that the choice of site for the settlement is strongly influenced by the direction of the slope, and that more settlements will choose to face south or as far south as possible. The south-facing slopes are less exposed to the cold northwesterly winds and receive more light in the cold winter months. More importantly, the south-facing slopes will be more vegetated due to the abundance of sunlight, which means they can provide more food resources than poorly lit slopes and are more suitable for human survival. The analysis of the buffer zone found that the proportion of settlements located within the buffer zone remained at around 50% in all three periods, indicating a high demand for a relatively stable water system.

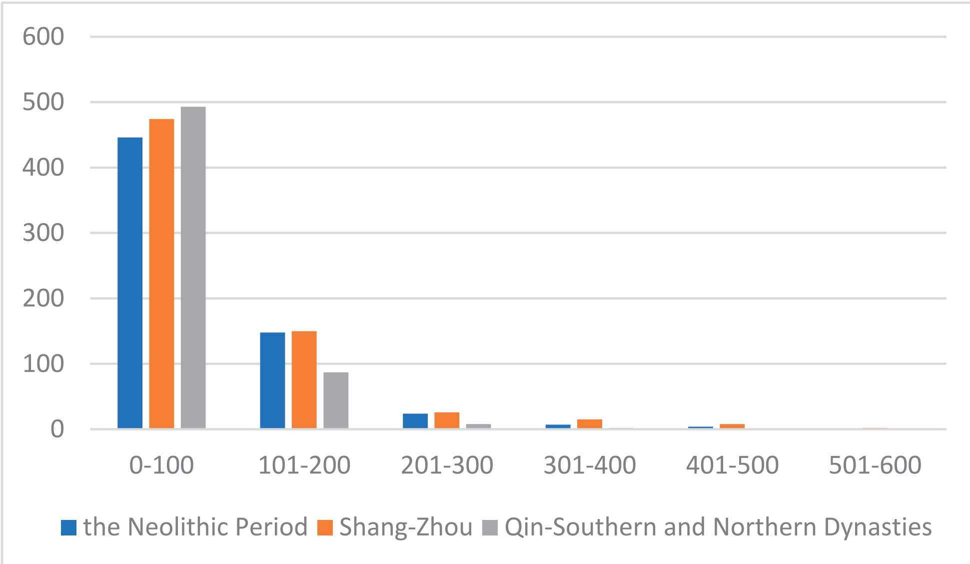

Figure 9. Elevation statistics of the distribution of settlements in different periods.

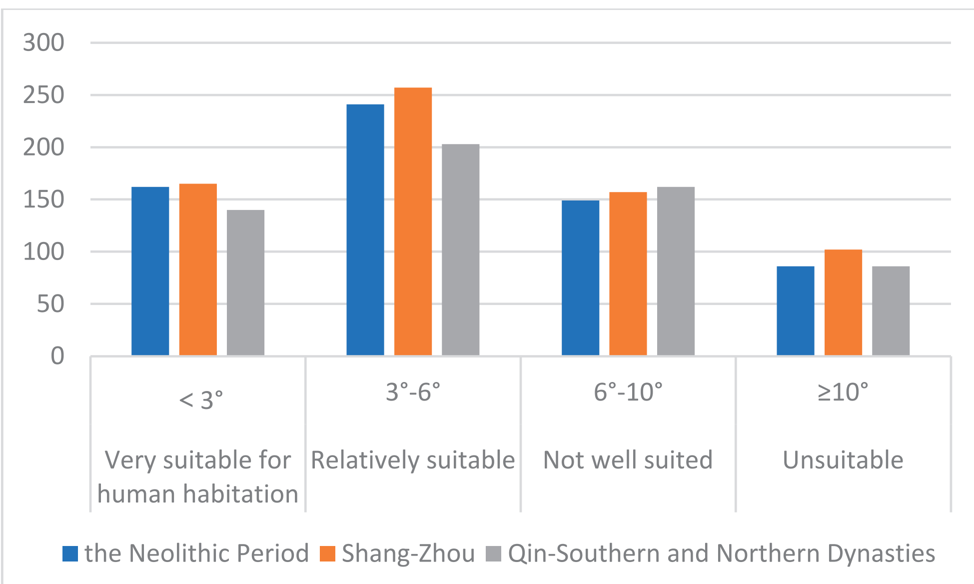

Figure 10. Slope statistics of the distribution of settlements in different periods.

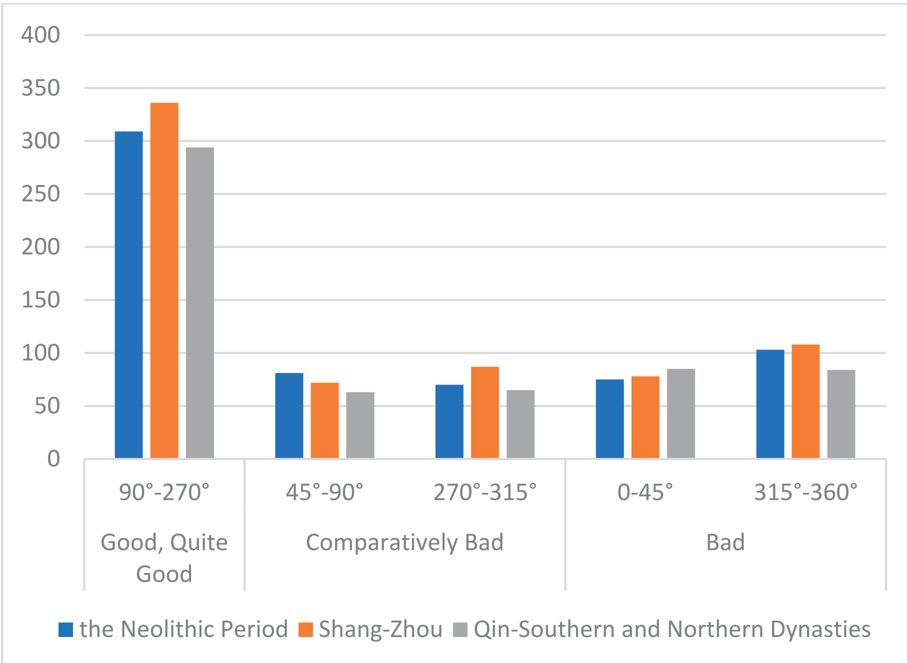

Figure 11. Aspect statistics of the distribution of settlements in different periods.

5. Conclusions

This study constructed a geographic information database of ancient settlements in the Luzhong region and mapped the dynamic overlay of the spatial–temporal distribution of these ancient settlements, in addition to visualising the historical distribution information of ancient settlements in the region. The database contains information on key attributes of the settlements in the region, providing a solid foundation for further research and practice. The map helps to build a historical context for the development of settlements in the Luzhong region and deepens the understanding of the development of traditional settlements in ancient China. Through the analysis of data on nearly 2000 settlements, the spatial and temporal distribution patterns of ancient settlements in the Luzhong region were derived; the development of ancient settlements in the region experienced three peaks of settlement construction during the Neolithic period, the Shang and Zhou periods, and the Qin to Northern and Southern Dynasties period. The distribution centres of the settlements experienced changes from a "single centre" to a "continuous belt" and to a "double centre". In different periods, the settlements were mainly distributed in alluvial plains with elevations below 100 m and with a flat topography (slope < 6). They also presented the characteristic of living by water. The settlements in the Luzhong region continuously developed over time, and the spatial development showed the characteristics of continuous local changes in the main body. Through an understanding of the distribution, morphology, and development of ancient settlements in the Luzhong area, we can glimpse settlement development in the core region of Chinese civilisation.

This study integrated the research methods of habitat and environmental science, archaeology, and cultural geography. It also used quantitative analysis tools, such as GIS, to analyse the spatial and temporal distribution and morphological characteristics of ancient settlements in the Luzhong region. The comprehensive investigation and systematic sorting of the spatial–temporal distribution of ancient settlements in the Luzhong region can enrich case studies of settlements and provide theoretical support for the conservation of the related cultural heritage. At the same time, as they are the predecessors to today's cities, towns, and villages, the study of these settlements also sheds light on the planning and construction of contemporary human settlements. In addition, the distribution of settlements in different periods is an important reflection of the interactions between people and places in the region. The study of the spatial–temporal distribution of ancient settlements in the Luzhong region can help to form a systematic understanding of the trends in the formation and development of the spatial system in the area in order to further explore the harmonious development of human–land relations and build sustainable cities and communities.

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Article

Presentation and Elaboration of the Folk Intangible Cultural Heritage from the Perspective of the Landscape

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Abstract: The folklore of intangible cultural heritage (FICH) is mainly expressed in folkloric activities, which include traditional festivals, living customs, production practices, folk beliefs, life rituals and folk costumes. The more reasonable and efficient ways to achieve conservation and transmission of FICH have become an urgent problem to be solved. Landscape presentation offers a potential method to address that by excavating the landscape characteristics of FICH based on its in-depth connotation and development history. This study aims to explore the cultural connotation of the FICH and extract the elements of landscape design, thus presenting and expressing the FICH using landscape as a carrier, to achieve the conservation and inheritance of the FICH. This research took the Taishun Hundred-family Feast culture, one of FICH in Sankui Town, Taishun County, China, as the study case, and extracted the landscape design elements in FICH after its content excavation and conducted presentation with cultural objectification, landscape narrative and contextualization. The results showed that the Hundred-family Feast culture contains rich landscape genes which can be divided into the ritual culture, food culture, festival culture and spiritual culture. Some of the elements in the Hundred-family Feast culture in terms of patterns, forms and colours for the content of activities, material carriers and spiritual places were also extracted for the landscape presentation. According to the different types and places of the Hundred-family Feast culture activities, the centre of Sankui Town is divided into four landscape thematic areas, namely the Hundred-family Feast cultural entrance experience zone, the food culture experience zone, ritual culture experience zone, and activity performance experience zone. The landscape element and spatial carriers were designed and illustrated for conserving and recovering the Hundred-family Feast culture, respectively. This study innovatively analyses the FICH from the perspective of the characteristics and constituent elements of the landscape and establishes a more reasonable framework system for the method of landscape presentation of the FICH in a structured and comprehensive manner. It enriches the theoretical system of intangible cultural heritage protection and its inheritance via landscape presentation methods for folklore activities.

Keywords: landscape presentation; intangible cultural heritage; rural landscape; folk activity; folk landscape

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1. Introduction

With the modernization of China and the increasing trend of globalization, the environment in which people live is constantly changing. The disappearance of heritage sites, the ageing of traditional artists, the hollowing out of villages and the impact of multiculturalism have put the cultural environment on which intangible cultural heritage depends in crisis. In recent years, China has paid great attention to protecting intangible cultural heritage and has made remarkable developments [1–4]. However, the protection process ultimately aims to achieve heritage conservation and development, which still needs to be studied from several perspectives for its sustainable development.

World cultural heritage comprises two categories: tangible cultural heritage and intangible cultural heritage. The first one is tangible, while the other is a cultural heritage in the intangible non-material form that depends on physical terms to express [5]. It originated in UNESCO's protection of natural and cultural heritage and the gradual realization that the dual natural and cultural heritage is essential [1]. In 2003, UNESCO adopted the Convention for the Safeguarding of the Intangible Cultural Heritage [6], which defines the concept and scope of intangible cultural heritage as the social practices, representations of ideas, expressions, knowledge, skills and related tools, objects, handicrafts and cultural spaces that are considered by communities and sometimes individuals as part of their cultural heritage [5]. In order to build on the actual situation of cultural heritage protection in China, the concept of intangible cultural heritage is clearly defined as all kinds of traditional cultural expressions (such as folklore activities, performing arts and traditional knowledge and skills) and cultural spaces that have been passed down from generation to generation by people of all ethnic groups and are closely related to the lives of the masses [7]. Specifically, the scope of intangible cultural heritage includes oral traditions, traditional performing arts, customary activities, rituals, festivals, traditional folk knowledge and practices concerning nature and the universe, traditional handicraft skills, and cultural spaces related to the above-mentioned expressions [8,9].

As a relatively comprehensive category of intangible cultural heritage in China, the folklore intangible cultural heritage (FICH) is mainly expressed by folkloric activities which contain several items including traditional festivals [10,11], living customs, production practices, folk beliefs, life rituals and folk costumes [12,13]. These activities were held by the people of a particular region as commemorative celebration for ancestor worship, festival celebrations, harvest celebrations and live entertainment [6,14]. FICH embodies the iconic local culture and is passed on with the group as the primary bearer in a specific cultural field [6]. Given its rich forms of expression and unique space for cultural expression, it fully reflects the local regional culture, religious beliefs and folk customs and has important diversified values. It is, therefore, necessary to deepen and strengthen the protection and transmission of the folklore intangible cultural heritage, and how to use more reasonable and effective methods to achieve the protection and transmission of the folklore intangible cultural heritage has become an urgent problem to be solved [15]. At the same time, the increasing quality of social and economic development and the people's higher requirements for a better life have made it possible to preserve intangible cultural heritage through landscape presentation. It can better show the cultural connotation, be close to people's lives and enrich the living landscape uniquely. It will also enhance people's passion for learning about intangible cultural heritage and their awareness of its preservation and preserve local cultural memory.

The landscape presentation of intangible cultural heritage is a combination of intangible cultural heritage and landscape that by excavating and analysing the landscape characteristics of intangible cultural heritage, and then presenting the landscape as the cultural carrier of intangible cultural heritage [16–19] In this way, it not only allows the concrete things to be felt visually but also the cultural atmosphere to be felt abstractly through the other senses, bringing about an infectious effect [20,21]. In the formation and development of intangible cultural heritage, facilitated by the human and natural elements of the landscape, spiritual culture is formed that has been passed down from generation to generation. With the development of history, spiritual culture can be expressed through new material forms and ways of expressing spiritual connotations. The intangible cultural heritage landscape combines humanity and nature, linking intangible cultural heritage and having aesthetic and cultural value [22].

The landscape presentation of intangible cultural heritage involves the theory of landscape genes and semiotics. Landscape genes are the different cultural elements on the landscape, which are the core factors that make up the cultural landscape. The cultural landscape is compared to an organism, and the genes of the landscape are similar to the cultural genes of the organism [23]. The most characteristic intangible cultural heritage landscape elements are excavated and deconstructed into fundamental landscape genes that cannot be further decomposed [24]. In turn, the cultural content of intangible cultural heritage can be expressed more comprehensively and logically. By analysing the decomposed landscape genes one by one, the causes, characteristics and influences of the culture can be more clearly understood, and the landscape design elements can be extracted for use in landscape expression. Symbols are signs that represent or explain what is being referred to and are divided into pictorial, indexical and symbolic symbols. People can communicate through the connection of these symbols, and the message of the symbols will continue to spread and develop [1]. The study of semiotics is broad and has applications in many fields. Intangible cultural heritage such as language are cultural symbols that are recorded and transmitted. Applying semiotic theory, intangible cultural heritage is used as a carrier in the landscape, and the various landscape elements of intangible cultural heritage are presented in terms of colour, form and material, and ultimately, the cultural connotations are presented in the form of a landscape.

Therefore, in this context, this study aims to explore the cultural connotation of the FICH and extract the elements of landscape design, thus presenting and expressing the FICH using landscape as a carrier, to achieve the conservation and inheritance of the FICH. This study takes the FICH of Taishun's Hundred-family Feast as the study case and investigates its in-depth connotation and development history, so as to extract design elements and apply them to the landscape planning and design of Sankui Town, Taishun County, to present the Hundred-family Feast culture in the form of landscape, and thus promote the protection, inheritance and development of Hundred-family Feast intangible cultural heritage.

This paper attempts to explore a feasible means of landscape presentation of the FICH, which can promote the exchange and progress of research in multiple disciplines and expand the academic research perspectives on intangible cultural heritage conservation and landscape planning and design. This paper enriches the theoretical system of intangible cultural heritage protection and its landscape presentation methods for folklore activities. This paper also innovatively analyses the FICH from the perspective of the characteristics and constituent elements of the landscape and establishes a more reasonable framework system for the method of landscape presentation of the FICH in a structured and comprehensive manner.

2. Research Methodology

2.1. Study Case

The Taishun Hundred-family Feast culture is located in Sankui Town, Taishun County, Wenzhou City, Zhejiang Province (as shown in Figure 1). Sankui Town is located in the middle of Taishun, is an essential township for trade and transportation, and is the most active area for human activities. The total area of the town is 64.9 km^2, with 16 villages and a total population of 23,002. Sankui Town has a comfortable climate all year round, with plenty of rainfall, cool summer and warm winter. The scenery in each season has its characteristics, including freezing fog, the sea of clouds, ice waterfalls, azalea sea, ancient red maple paths and terraced fields, the mountains rolling, the forests lush and rolling, and the ecological environment is stunning.

The Taishun Hundred-family Feast was first developed from the "making of spring blessings", which began in the Northern Song Dynasty, more than 970 years ago, and is a traditional custom with local solid characteristics and profound history and culture. The purpose of the festival is to gather clansmen, discuss clan affairs, pray for a good harvest, and ensure peace, and it is a prayer ritual within the clan. During the Southern Song Dynasty, the people of Zhangzhai Village fled from Hebei to Sankui Town, Taishun to escape the war and took root here again. The scale of the ceremony was only a few to a dozen tables. During the Ming and Qing dynasties, this custom became so prevalent that the Hundred-family Feast gradually became an open-ended entertainment event, welcoming guests from outside the clan to join in the feast, which grew in scale and slowly evolved into a gathering of fellowship and exchange. The event was also rich in activities, including singing, puppet shows, fireworks, dragon lantern dances, street parades, etc. In 2009, this folklore event was included in the third batch of the Intangible Cultural Heritage List of Zhejiang Province. In 2010, the Taishun Hundred-family Feast was entered into the Guinness Book of Records as the "First Blessing Feast in China". Today, the scale of the banquet has reached thousands of tables, with participants from all over the country, making it a folklore event that symbolizes harmony and unity. In 2020, the town of Taishun Sankui launched the "Daily Hundred-family Feast" project [25] to develop the Hundred-family Feast culture as a form of intangible cultural heritage tourism.

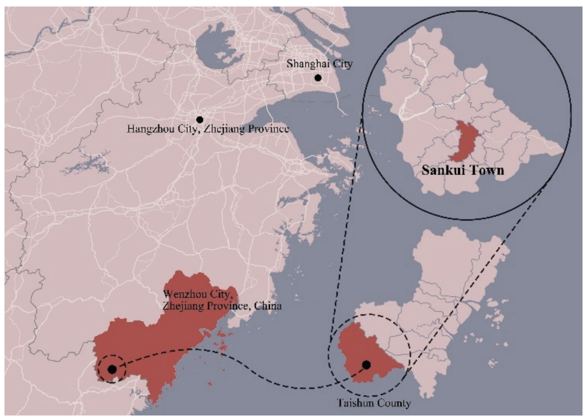


Figure 1. The position of Sankui Town, where the Taishun Hundred-family Feast culture exists.

2.2. Research Method

In this study, we aim to explore the cultural connotation of the FICH and extract the elements of landscape design, thus presenting and expressing the FICH using landscape as a carrier, to achieve the conservation and inheritance of the FICH. Therefore, it is necessary to introduce how the content of FICH was collected, how they were extracted for landscape elements and how these extractions were presented for disclosing the results (Figure 2).

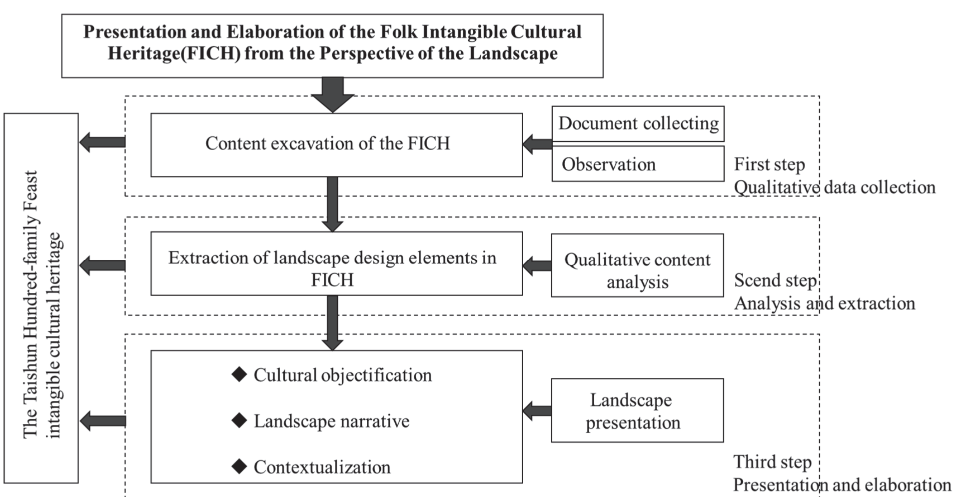


Figure 2. The research process of presentation and elaboration of the folk intangible cultural heritage from the perspective of the landscape.

2.2.1. Content Excavation of the FICH

When presenting the FICH in landscape form, the first step was to explore the landscape characteristics of the landscape gene mining techniques. The content excavation including landscape genes of the FICH was carried out using qualitatively document collecting and observation. These documents related to the Taishun Hundred-family Feast Culture include books, government report and academic articles. Observation was conducted in Sankui Town, Taishun County in 2021 and 2022. The FICH is a comprehensive unit of cultural information and requires a comprehensive analysis of the cultural vectors on which its historical formation and development depend. In applying landscape gene theory, it is necessary to explore the appropriate gene analysis methods according to folklore activity-based intangible cultural heritage characteristics. Perceptual mining, genealogical mining, geographical mining, meaning mining and tracing mining were used in this study. The perceptual mining method analyses some of the activities that are widely transmitted in the FICH. The genealogical mining method analyses the inheritance characteristics of the folklore activity of intangible cultural heritage. The geographical approach analyses the FICH's local physical and cultural characteristics of folklore activities. The meaning mining method analyses the spiritual connotations of folklore activities with the method of tracking the development of it in time and the historical perspectives.

Establishing a reasonable genetic index system for folklore activity-based intangible cultural heritage landscapes is the most effective way to explore their landscape characteristics [26]. The FICH is expressed by the material carrier, the iconic culture formed by the regional characteristics, the group identity inherited, and the inherited cultural imagery abstractly expressed through cultural symbols [27]. Therefore, exploring the landscape characteristics of the formation, development and transmission of the FICH is an indispensable objective condition for exploring its landscape genes. Based on the characteristics of the intangible cultural heritage of folklore activities and several essential core elements, including the heirs and participants of folklore activities, the content and flow of folklore activities, and the materials on which folklore activities are based, a system of ten excavation indicators is established for the intangible cultural heritage of folklore activities, including activity characteristics, evolutionary characteristics, transmission carriers, imagery characteristics, etc. [28].

2.2.2. Extraction of Landscape Design Elements in FICH

Based on the content excavation of FICH and the qualitative content analysis of collected data, the landscape design elements were extracted from the landscape features in the four excavation indicators of the landscape genetic excavation system. The spatial structure and form of the landscape undertaking activities were determined according to the content of activities; the natural elements were identified based on the natural environment in which the culture evolved; the artificial elements in terms of pattern, colour and material were dictated by the morphological characteristics of the material carrier on which the cultural heritage depends; and the psychological needs of people were analysed in light of the beliefs and spirits expressed in the cultural imagery.

2.2.3. Landscape Presentation Method for FICH

The last step was the landscape presentation through cultural objectification, landscape narrative and contextualization based on the landscape elements extracted above.

(1) Cultural objectification

Using the inheritance carrier of the FICH or physical objects used in activities, the landscape is expressed through abstraction and metaphorical symbolism, relying on sculptures, scenic walls, public service facilities and architecture in the landscape. According to the physical shape, colour and material of the cultural inheritance carrier, abstraction and simplification are carried out, and the elements are recombined together to form a new landscape. The shape is abstracted into contour lines based on the shape of the object, then transformed into a surface based on the general form, and the whole can be materialized into a solid or hollowed-out form Chen, et al [1]. As different colours reflect the unique cultural characteristics of the local area, the primary matching colours of the cultural carrier to express the cultural connotations were used. Some colours have cultural symbolism, for example, red represents Chinese culture. The use of traditional materials and modern materials to express cultural connotations will have different expressions, the former being more archaic and the latter more visually striking. The cultural carrier of textual language can be expressed directly with the help of landscape facilities, paving etc, whose content can be detailed or generalized.

(2) Landscape narrative

The local cultural story is told to people using landscape design, including the story of the origin of FICH, the development process, and the story of holding folklore activities [29]. It can be expressed through sculptures, relief patterns, digital virtual scenes, etc. The narrative is completed through successive different activity spaces in the overall spatial structure of the landscape, and different thematic episodes are strung together through the tour route to meet people's material and spiritual experiences so that people can better accept and understand the cultural connotations through the landscape [7]. Through the fragmented plot of the story, the landscape space is combined and created using landscape vignettes that match the characteristics of the landscape, triggering people's emotions and imagination, strengthening the cultural attributes of the landscape and the infectious power of the landscape space [30].

(3) Contextualization

Folklore activities rely on the landscape space to hold various activities, for example, participatory activities and exhibition activities. As different activities have different activity spaces, it is necessary to create a corresponding landscape activity atmosphere for different spaces. The landscape atmosphere can be created through human hearing, visuals and participation. In some performances and ceremonial folklore activities, people can communicate, participate and interact to enhance the vitality of the landscape space. Aurally, the special cultural atmosphere is felt through the playing of some musical instruments and the sounds people make during the activities. Visually through plants, sculptures, paving, etc., ceremonial activities have a solemn atmosphere to create a different atmosphere with a sense of neatness and sequence.

3. Taishun Hundred-Family Feast Intangible Cultural Heritage Landscape Presentation

3.1. Taishun Hundred-Family Feast Culture Content Mining

As shown in Table 1, according to the established index system for the excavation of the landscape characteristics of the FICH, the outcome of the landscape genes of the Hundred-family Feast culture was obtained. It can be found that the Hundred-family Feast is held at a specific time of the year, that is, the Lantern Festival. The inheritance of the FICH relies on the clan of Zhangzhai in Sankui Town, gradually expanding the scope to the group inheritance of the surrounding participants. Some of these activities are closely linked to the cultural space, and there is a strong chronological relationship between activities and events, and the layout of the different activities in the presentation of the landscape directly influences the route people experience. From the point of view of cultural symbols in the landscape, there is nothing more closely linked than the Chinese character of "fortune" in the Hundred-family Feast culture, which is inseparable from most of the content, both in terms of the name of the event and in terms of cultural beliefs, and is represented by the colour red. The whole event has various activities and thus has different cultural expressions. According to the results of the landscape gene excavation, the content of the activities and cultural beliefs can be divided into four cultural themes: ritual culture, food culture, festival culture, and spiritual culture (as illustrated in Figure 3), which help to express the spatial structure of the landscape. The ritual culture includes the spring rituals, ancestral rituals and street strolling activities; the food culture includes the entire menu of the banquet and the flow of activities; the festival culture includes some of the special performances derived from it; and the spiritual culture shows the spirit and beliefs of the local people.

Table 1. Landscape gene mining results of the intangible cultural heritage of Taishun Hundred-family Feast folk activities.

Characteristic	Indicators	Taishun Hundred-Family Feast Culture
Activity Features	Type of activity	Traditional Festivals
	Activities	Spring and ancestral rituals, ritual ceremonies, street tours, a banquet of "lucky wine", dragon and lion dances, folk music performances, pyrotechnic puppets shows, dragon and horse lantern dances and fireworks displays.
Evolutionary Features	Date of origin	Northern Song Dynasty (c. 900 years ago)
	Place of origin	Sankui Town, Taishun County
	Cultural evolution	It began as a family prayer for good fortune and peace and took root in the town of Sankui after fleeing during the war.
Inheritance Features	Ethnic attributes	Han, Chinese
	Inheritance method	group inheritance
	Inheritance carriers	Dragon and phoenix lion lamps, a Hundred-family feast dishes, puppets, red lanterns, firecrackers, ritual chants, dragon and lion dance
Imagery Features	Cultural beliefs	The spirit of honouring ancestors, praying for a good harvest, blessing peace, harmony and unity.
	Cultural spaces	Linshui Palace, the village street, the ancient house of Zhangzhai, the Zhang Ancestral Hall, and the Cultural Hall.

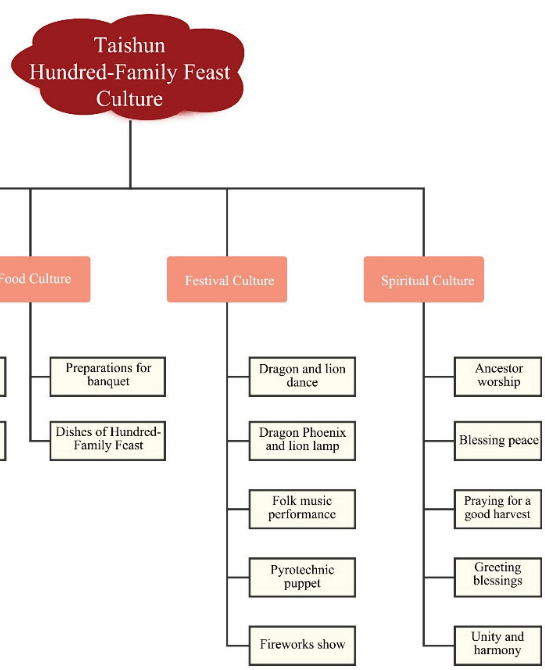


Figure 3. Analysis of Taishun Hundred-family Feast culture (See more in Appendix A).

3.2. Analysis of the Landscape Presentation Carrier of the Taishun's Hundred-Family Feast Culture

Based on the results of the excavation of the culture of the Taishun Hundred-family Feast, some cultural elements were extracted in terms of patterns, forms and colours for the content of activities, material carriers and spiritual places (e.g., Figure 4). In Zhangzhai village, the most well-preserved is the ancient house of Zhangzhai, the patterns and styles of the ridge decorations and guardrail of this spiritual place were extracted and applied to the landscape design. The pyrotechnic puppet itself is an intangible cultural heritage whose spiritual beliefs are to please and honour the gods and ancestors. The form and structure of the pyrotechnic puppets and their working principles are extracted and used as landscape elements. The street parade is a parade that passes through every street of the village. According to the extracted images, the use of colour is very pure, with each object and costume in red and yellow, while the red lanterns with the word fortune hanging on both sides of the street can better bring out the festive atmosphere, the colours are used to create the colour scheme of the landscape, and the red lanterns with the word of fortune are used to create the atmosphere of the landscape. The dragon and phoenix lion lamps are a performance activity in Taishun's Hundred-family Feast culture, and their unique shape and colour scheme are applied to the expression of the landscape. The puppet show is also one of the performance activities, extracting the working principle and characteristics of the puppet show which uses silk thread to control the form of the puppets to express the landscape. The bowls and chopsticks, rice dishes, round tables and square chairs of the banquet form a table, while table after table, from the cloth filling the ancient house, the banquet is held in larger and larger numbers, and then extended to the street, to the forms and dishes used in the landscape vignettes.

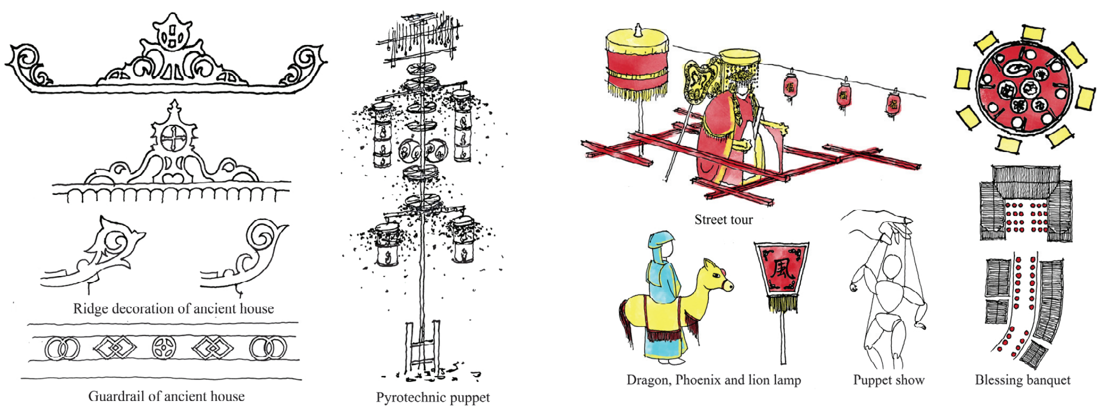


Figure 4. Extraction examples of elements of Hundred-family Feast culture in Taishun.

3.3. Landscape Presentation of Taishun Hundred-Family Feast Culture—The Landscape Design of Sankui Town

The landscape presentation of the Taishun Hundred-family Feast culture is located in the centre of Sankui town, Taishun County, Wenzhou City, Zhejiang Province, which is the birthplace of Taishun's Hundred-family Feast culture. The northern end of the site is connected to the Jianxue Line and is the entrance to Zhangzhai village. The interior of the site is bounded by a San Kui stream running north-south through it, with a road on each bank of the stream, Shuguang Road being the one that runs immediately along the riverbank. Yanshui Road is a relatively busy commercial road with shops on both sides, and the two banks are connected by several bridges. Near the east side of Yanshui Road is the Zhangzhai Ancestral Hall, an important site for ritual and cultural worship. There is also an important road to the north and south, Guiyan road, where the street is mostly dominated by spaces inhabited by villagers, including the spiritual and cultural space of the ancient house of Zhangzhai, which is located on the eastern side of Guiyan road. Other roads connect the residents' daily life spaces and residential spaces (shown in Figure 5).

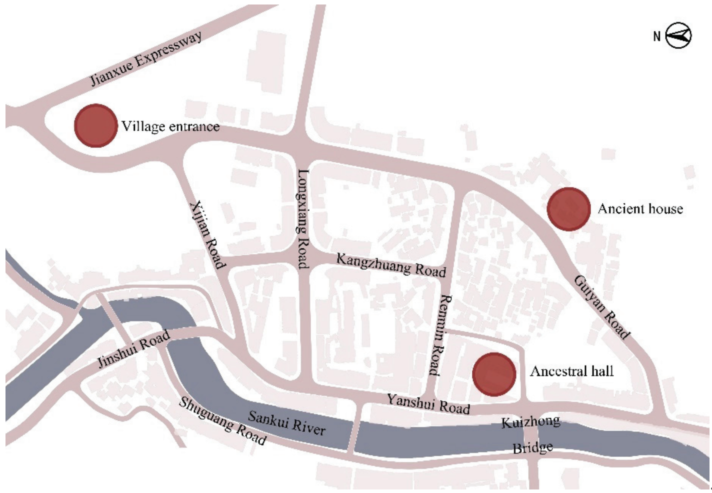


Figure 5. Current situation of the centre in Sankui Town.

3.3.1. Planning and Design Objectives

The Taishun Hundred-family Feast culture itself is intangible, but what is embodied in the culture contains material things, such as related objects, buildings and neighbourhoods, as well as non-material things, such as beliefs and performances. How to present the appearance and inner spiritual connotation of the culture through the form of landscape and how to improve the difficult points of cultural conservation is the key research content of the cultural landscape design of Taishun Hundred-family Feast, which mainly contains the following points.

(1) The landscape design of the village should combine preservation and creation, consider the village as a whole, unify and adapt the overall style, restore the historical style of the buildings, highlight the local and regional characteristics and integrate the culture of the Hundred-family Feast into the landscape design according to the environmental features and the overall pattern, create a landscape pattern that is compatible with the culture and creates an overall sense of cultural atmosphere.

(2) Reasonable use of natural environmental features for landscape design, such as the use of riverside to create a water landscape and water-friendly space, the use of site height differences to create different ornamental space, performance space and vertical landscape space, or some waterfall landscape combined with water features.

(3) Create an experiential landscape with the culture of the Taishun Hundred-family Feast as the core. The most important thing about intangible cultural heritage is that people can participate in the experience or interact with it. Through the experiential landscape, people are attracted to participate and interact with it spontaneously so that they can feel the cultural connotations of the Hundred-family Feast in a more comprehensive and immersive way while at the same time meeting the functions of activities required by local people in their daily lives [31].

(4) Improve the construction of service facilities, such as a comprehensive service centre, a comprehensive guidance system, sufficient parking space, etc. The pattern and traffic of the landscape space are planned reasonably and conveniently, and the functional partitioning of the landscape space is carried out in a reasonable and comfortable manner to fully meet people's needs.

3.3.2. General Layout

In order to achieve the aim of this study, five important spiritual places are used as the core of the Hundred-family Feast culture for landscape planning and design, namely the village entrance, the ancient house, the ancestral hall, the street and the riverside. The results of Taishun's Hundred-family Feast culture excavation were applied to landscape design through transforming the original natural landscape and creating landscape space and elements with activities and culture display relating to each core place. The Taishun's Hundred-family Feast culture thus can be displayed in a form of landscape to evoke the cultural memory of local people and create a more comfortable, beautiful and connotative venue for locals and visitors (shown in Figure 6).

Figure 6. General layout of Taishun Hundred-family Feast landscape presentation.

This study created a landscape spatial pattern of "one centre, one axis, two belts and four zones". The centre is the integrated public service centre of Sankui Town, and the axis is a landscape axis running through the northern and southern ends of Zhangzhai Village, with the northern end connecting the entrance to Zhangzhai Village and the Sankui Town Public Service Centre and the southern end being the convergence point of the two zones. The eastern side favours the experience of Taishun's Hundred-family Feast culture, while the western side favours the experience of leisurely living. The two belts are the Hundred-family Feast culture block experience and the leisure tour experience along Yanxi, which are two blocks with different experiences. The four zones are four major landscape theme zones. Based on the results of the excavation of Taishun's Hundred-family Feast culture, the folklore activities of different types and places are divided into themes, namely the Hundred-family Feast cultural entrance experience zone, the food culture experience zone, ritual culture experience zone, and activity performance experience zone (as illustrated in Figure 7).

The two belts and four zones are linked together by roads and greenery, each with different thematic content, telling the story of each cultural connotation of Taishun's Hundred-family Feast culture with each unique thematic block. Through experiential, thematic and interactive landscape creation, people can experience the different folklore activities in different landscape spaces, enabling them to understand and develop the intangible cultural heritage of Taishun's Hundred-family Feast in a more in-depth and spontaneous manner. According to the four different cultural expressions in the Taishun Hundred-family Feast culture, namely food culture, ritual culture, festival culture and spiritual culture, they are expressed through the four landscape theme blocks, while the spiritual culture is integrated into each theme block to show the way of the atmosphere created through the landscape, as shown in Table 2.

Figure 7. Landscape spatial structure analysis diagram of Taishun Hundred-family Feast.

Table 2. Landscape space and cultural activities.

Landscape Spaces	Spatial Form	Cultural Content	Activities
Hundred-family Feast culture entrance experience zone	Piazza	Comprehensive displays of the Hundred-family Feast culture (origin, development, various elements)	The exhibition, education, banqueting activities, prayers, resting, playing, cultural exchange
Food culture experience zone	Street side, courtyard	Food culture in the Hundred-family Feast culture	The exhibition, education, banqueting activities, resting
Ritual culture experience zone	Street side, courtyard	The Ritual Culture in the Hundred-family Feast culture	Exhibition, education, meditation, rituals and banquet activities
Activity performance experience zone	Piazza, Mountain	Festival culture in the Hundred-family Feast culture	The exhibition, folklore shows, lectures, imitation learning, watching, resting, walking, sightseeing tours
Hundred-family Feast culture district experience zone	Block	Comprehensive displays of the Hundred-family Feast culture (various event elements)	The exhibition, education, street strolling events, banqueting activities, gatherings, fitness, watching, photographing, resting and playing
Leisure tour experience zone	Blocks along the river	Comprehensive displays of the Hundred-family Feast culture (Natural features)	The exhibition, watching, walking, resting

3.3.3. The Landscape of the Hundred-Family Feast Cultural Entrance Experience Zone

The landscape of the Hundred-family Feast cultural entrance experience zone is divided into two parts: the Hundred-family Feast Cultural Square on the east and the Sankui Town Comprehensive Public Service Centre on the west (as shown in Figure 8). Through the Hundred-family Feast Cultural Square, the connotation and development history of Taishun's Hundred-family Feast culture is comprehensively told. Through the Sankui Town Integrated Public Service Centre, people can be better guided to understand the culture and experience the landscape space, and the service facilities are enhanced to improve people's convenience.

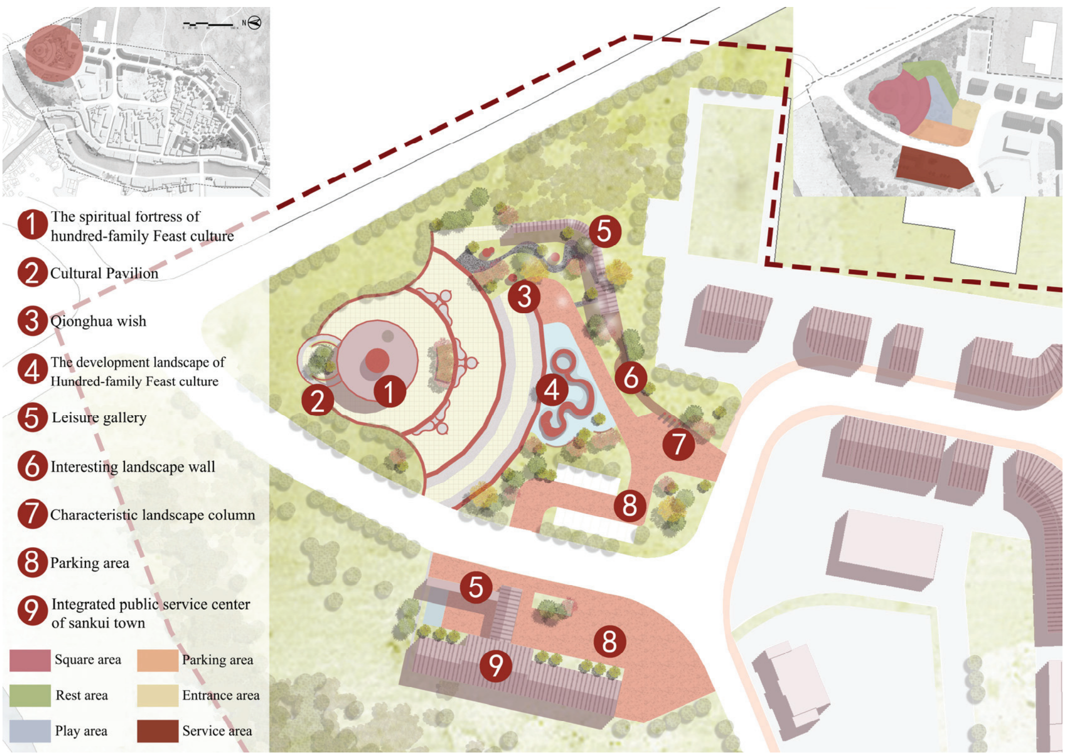
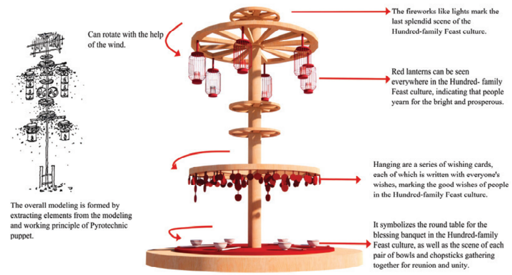


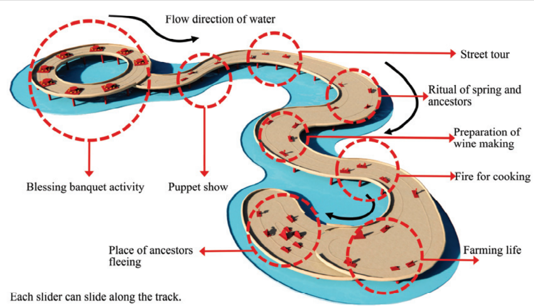
Figure 8. The plan of Hundred-family Feast cultural entrance experience zone landscape.

There are two landscape element carriers presented in this zone, namely, the spiritual fortress of hundred-family Feast culture and the development landscape of the Hundred-family Feast culture (Table 3). The overall shape of the spirit fortress is extracted from the shape and working principle of the Qionghua pyrotechnic puppet, one of the puppets in Taishun County. It is a visual representation of the spirit of the Hundred-family Feast culture. The Qionghua puppet is rotated by the power of firecrackers, while the spirit fortress is rotated on each level by the wind. The storyline of the development of the Taishun Hundred-family Feast culture is presented through a long, curved waterfall with three levels flowing from each level to the next.

The Hundred-family Feast Cultural Square as the spatial carrier is divided into an entrance area, a square area, a rest area, a play area and a parking area (Table 3). The main entrance is opposite to the public service centre, and the secondary entrance is connected to the car park. The integrated public service centre including indoor spaces and outdoor resting spaces is a key step for improving the infrastructure.

Table 3. The landscape element carrier and spatial carrier in the Hundred-family Feast cultural entrance experience zone.

<table>
<tr><th></th><th>Figure</th><th>Explanation</th></tr>
<tr><td rowspan="2">Landscape element carrier</td><td>

The spiritual fortress of hundred-family Feast culture</td><td>The overall shape of the spirit fortress is extracted from the shape and working principle of the Qionghua pyrotechnic puppet. The colours used are the distinctive wood colour of the ancient buildings of Zhangzhai and the red colour in the Hundred-family Feast culture. The cultural and spiritual fortress of the Hundred-family Feast is divided into four levels, which represent different cultural symbols, and each level has a different meaning in terms of elevation. The first and lowest level symbolizes the round table of the Hundred-family Feast culture and the sight of each pair of chopsticks and bowls gathered together in unity. On the second level are strings of wishing cards, a symbol of the wishes and expectations of all people. It signifies that people of the Hundred-family Feast culture pray for good fortune and make good wishes. The third floor is hung with the red lanterns found everywhere in the Hundred-family Feast culture for peace, signifying that people yearn for light. The uppermost layer is the closest to the sky, showing the glorious light in the form of fireworks in the sky, and the fireworks are also the last activity of the Hundred-family Feast culture, marking the final glorious scene of the Hundred-family Feast culture with fireworks as the end of the whole folklore activity.</td></tr>
<tr><td>

The development landscape of the Hundred-family Feast culture</td><td>The storyline of the development of the Taishun Hundred-family Feast culture is presented through a long, curved waterfall. It is divided into three levels, with the water flowing from each level to the next. The direction of the storyline from the beginning to the end is from low to high, which also signifies the spiritual will of the ancestors to go upstream and settle down, thus forming the Taishun Hundred-family Feast culture. The storyline is divided into several stories, from the beginning to the end: the ancestors travel through the mountains to reach this place, learn how to farm, cut wood and firewood to prepare the ingredients for cooking, prepare wine and start the spring festival for the ancestors, carry out the street parade, perform the puppet show and have a banquet with families together.</td></tr>
</table>

Table 3. *Cont.*

	Figure	Explanation
Landscape spatial carrier	 The Hundred-family Feast culture square	The Hundred-family Feast Cultural Square as the spatial carrier is divided into an entrance area, a square area, a rest area, a play area and a parking area. The resting area is a relatively quiet landscape space with a resting and viewing pavilion. On one side of the pavilion is a wall displaying the history and development of Taishun's Hundred-family Feast culture in the form of words and patterns. The play area is a playful landscape space with the development of the Hundred-family Feast culture tour as the core, which comprehensively shows the historical origin, development history and activities of the Hundred-family Feast culture in Taishun and helps people to understand the Hundred-family Feast culture more.
	 The Integrated Public Service Centre in Sankui Town	The integrated public service centre, a key step in improving the infrastructure, consists not only of indoor spaces but also outdoor resting spaces. The service centre can meet the needs of people to understand the culture of Taishun Hundred-family Feast and the internal environment of Zhangzhai Village and to know the various locations and routes to experience the cultural landscape of Taishun Hundred-family Feast, as well as to meet the needs of people for accommodation, food and shopping.

The square creates a solemn atmosphere with a regular and symmetrical spatial pattern and then forms a new representative spiritual symbol through the tall cultural and spiritual fortress of the Hundred-family Feast in the centre as the visual centre of the square. The activities undertaken in the square include a banquet where everyone can gather to experience the blessing ceremony of the Hundred-family Feast, and people can also experience some local non-traditional cultural activities: puppet writing, rice cake making, bamboo weaving, rice sculpture, paper cutting, dragon dance, fried tea and snacks.

3.3.4. The Landscape of the Food Culture Experience Zone

The landscape of the food culture experience zone is mainly divided into three parts, one is the food culture display tour area along the street outside the ancient house, one is the Hundred-family Feast Experience Centre inside the ancient house, and one is the Hundred-family Feast Cultural Exchange Hall adjacent to the ancient house (as shown in Figure 9). The food culture exhibition and tour area provide detailed information on the names, origins, meanings and production methods of the dishes in the Taishun Hundred-family Feast culture, as well as the local food characteristics and eating habits; the Hundred-family Feast Experience Centre provides direct experience of the banquet from preparation to the opening of the banquet; and the Hundred-family Feast Culture Exchange Hall allows you to learn first hand about the activities related to the Taishun Hundred-family Feast culture.

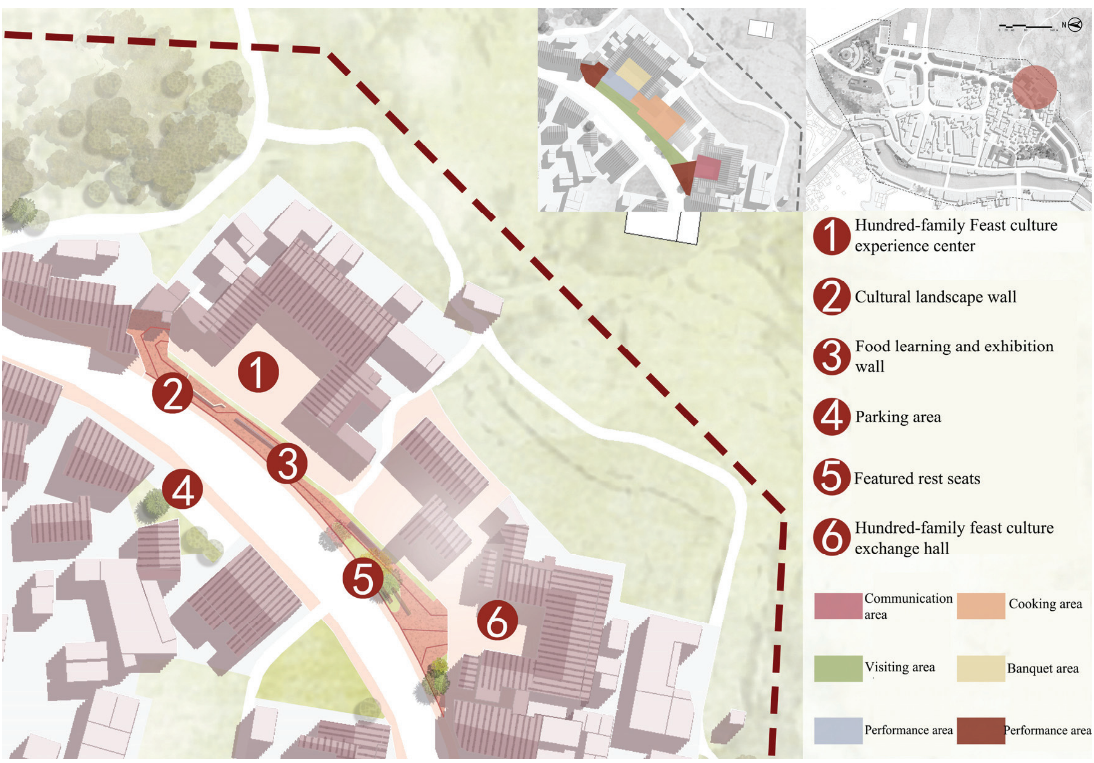


Figure 9. Plan of food culture experience zone landscape.

The landscape element carrier in this zone is the dishes display wall that showcases the elements of the Hundred-family Feast culture in the form of a banquet of blessings. The structure of the wall is characterized by the style of ancient local architecture. The dishes in the banquet are modelled and displayed in the form of round tables and benches, and each dish is linked to the paving of how to prepare it. Therefore, it enhances the exploration of the landscape and contributes to the understanding of the food culture of Taishun's Hundred-family Feast culture (as shown in Figure 10). Furthermore, the spatial carrier for landscape activities in this zone is composed of an internal and external courtyard. The internal courtyard is reasonably divided into the various working areas of the banquet, with a clear division of labour to facilitate the activities of the banquet. The external landscape is located along Guiyan road, not only attracting people who want to learn about food culture but also providing a space for pedestrians to rest and watch. The cultural wall shows the local culinary characteristics and the names of the dishes, and the materials used to make them. Meanwhile, the interactive mobile phone can be used to scan the code to understand the process of making each dish, enhancing the interaction between people and the landscape (as described in Figure 11).

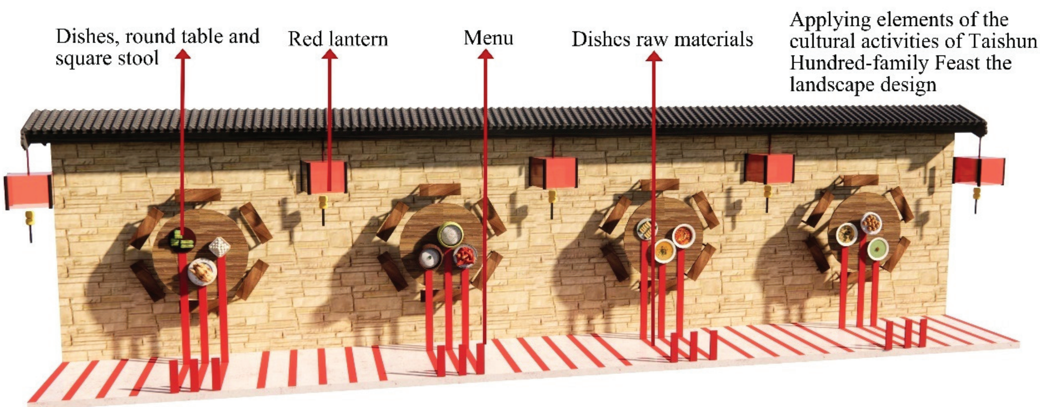


Figure 10. Dishes display wall.

Figure 11. Hundred-family Feast food culture experience zone landscape space.

3.3.5. The Landscape of Ritual Culture Experience Zone

The landscape of the ritual culture experience zone is divided into two parts, an area outside the ancestral shrine bordering the neighbourhood and a ritual space inside the ancestral shrine (as illustrated in Figure 12). The contemplation area is used to tell the story of the culture of spring rituals and the introduction of the ancestors, and the ritual space is used to perform rituals related to spring rituals.

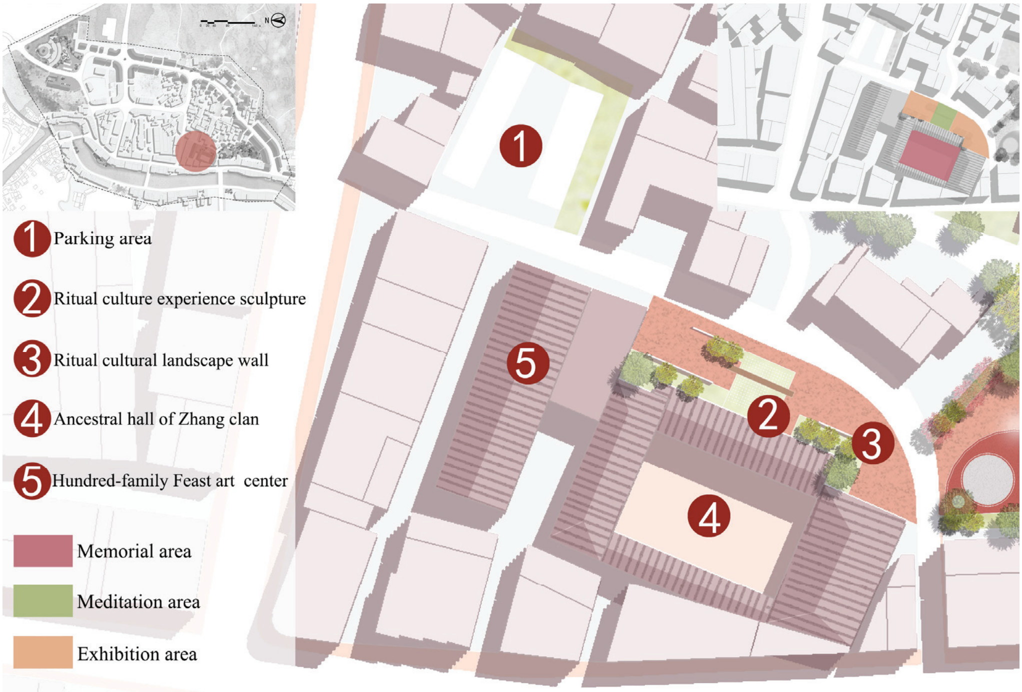


Figure 12. Plan of Ritual culture experience zone landscape.

The design concept of the festival culture experience sculpture comes from the custom of hanging bamboo bars with bamboo leaves on the roof during the Hundred-family Feast culture so that the ancestors can stay and celebrate the Lantern Festival with the people. The form is based on the outline of the Zhangzhai village building, with the main house in the middle and the compartments on the left and right sides. The bamboo bars are used to show the outline in an array of different heights so that people can associate it with the form of ancient buildings, and a pathway is left in the middle, which also passes through the main house from the middle, where people stay with a feeling of remembrance and contemplation, forming a space for infinite reverie. Furthermore, the plants on the bottom side grow upwards along the bamboo bar, which not only softens the hard sculpture but expresses the symbolism of life and positivity is used to commemorate the ancestors and to send blessings to the people through the ancestors resting on the bamboo bar with the green colour (as shown in Figure 13).

The overall atmosphere created by the ritual culture theme landscape is tranquil, simple and serious, and the overall layout is very neat and tidy, with green bamboo as the main planting to support the cultural atmosphere. The landscape space outside the ancestral shrine allows people to learn about the cultural content, the deeds of the ancestors and the development of the clan through the ritual culture wall. The landscape atmosphere creates a sense of remembrance for the ancestors. Inside the ancestral shrine, people can experience the rituals of spring rituals, feel the ritual culture and beg for the blessing of their ancestors (as shown in Figure 14).

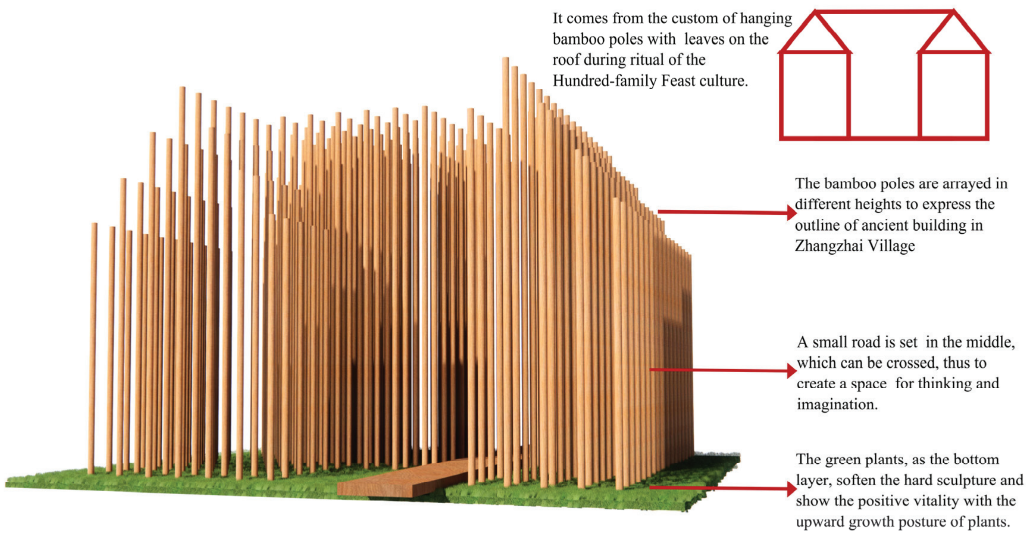


Figure 13. Ritual culture experience sculpture.

Figure 14. Ritual culture experience landscape space.

3.3.6. The Landscape of Activity Performance Experience Zone

This thematic landscape is divided into two parts, the outdoor performance theatre on the north side and the viewing platform on the south side (as shown in Figure 15). The outdoor performance theatre showcases each of the performances of the Taishun Hundred-family Feast culture, while the viewing platform not only allows you to climb up the mountain to see the natural landscape but also to stand on high ground and watch the performances.

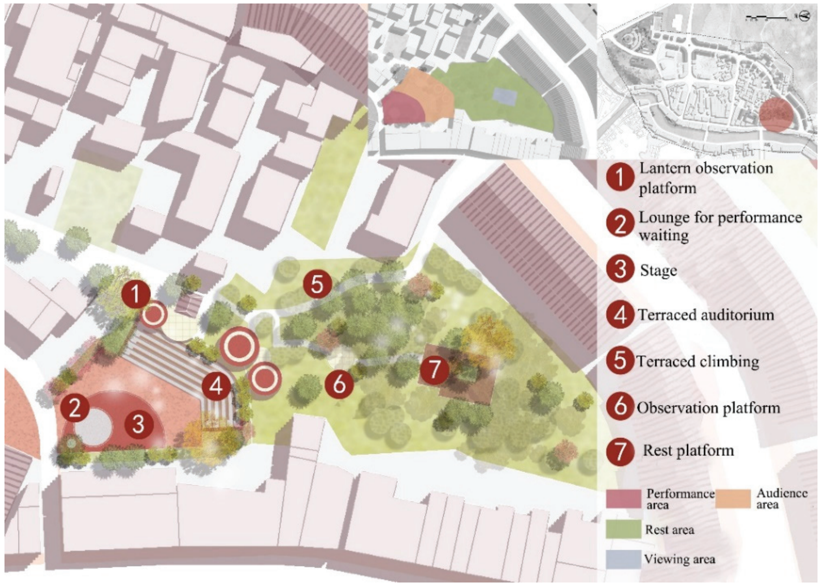


Figure 15. Plan of Activity performance experience zone landscape.

The lantern viewing platform uses the red lantern, the most representative of Taishun's Hundred-family Feast culture, as a landscape element. The skeleton form in the lantern is used as the supporting structure and railing of the viewing platform, the red body of the lantern is used as the top of the landscape platform to shelter from the rain, and the lantern's lamp holder is decorated on the top of the landscape platform. The whole form is combined similar to a red lantern hanging in a high place, full of good symbolic meaning (as illustrated in Figure 16).

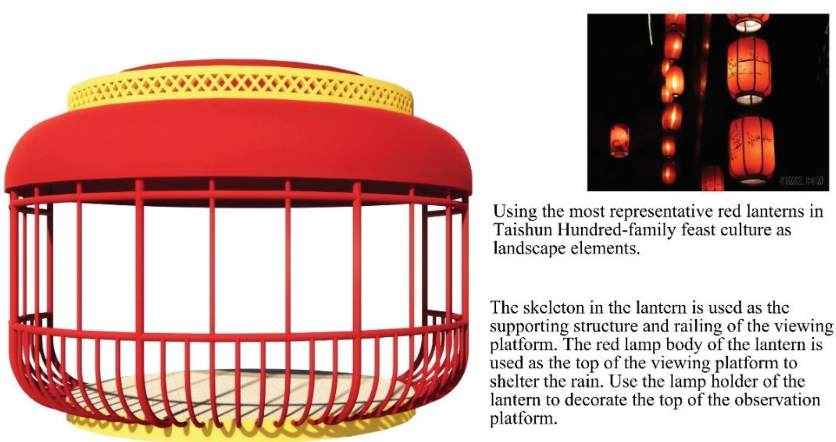


Figure 16. Lantern viewing platform.

The outdoor performance theatre is mainly used for the performance of activities such as puppet shows, folk music and so on in the Taishun Hundred-family Feast culture. In the centre is a large stage for the performers to take to the stage, with a small space for the performers to rest and prepare for some behind-the-scenes work. The audience is positioned directly opposite the stage, taking advantage of the height difference created by a wall behind the space to create a stepped outdoor theatre, providing a more comfortable and spacious viewing space. The performance evokes a cultural memory of the place and enhances the experience of the outdoor performance theatre landscape space (as shown in Figure 17).

Figure 17. Outdoor performance theatre.

3.3.7. The Landscape of the Hundred-Family Feast Culture District Experience Zone

The landscape of the Hundred-family Feast culture district experience zone is mainly divided into three parts: a traffic roundabout at the intersection of Guiyan Road and Longxiang Road, a street recreation and fitness space at the convergence of Guiyan Road and Renmin Road, and a rest and play space with the dragon and phoenix lion lamp as the main expression (as illustrated in Figure 18). The landscape island and unique sculptures set the atmosphere of the street, the recreation and fitness space show the elements and contents of the culture of the Taishun Hundred-family Feast, and the rest and play space show the cultural characteristics of the dragon and phoenix lion lamps.

There are two landscape element carriers that were proposed in the district experience zone. The first is the Fufang sculpture. It uses the street-tour activity of the Taishun Hundred-family Feast culture, where people carry the idol in a palanquin, and the flat structure of the palanquin on wood is selected and presented in the form of a sculpture. The overall structure of the sculpture is made up of interlocking red wooden sticks, with overlapping baffles supporting the structure of the sticks and the use of red glass to enhance the permeability of the statue. The red square in the centre is held up and protected by the interlocking structures around it, which is an important symbol, and the word “fortune” is used as a symbol of the square, which better reflects the importance and representativeness of the word “fortune” in the culture of the Taishun Hundred-family Feast (as shown in Figure 19). The second is the dragon phoenix and lion lamp that derives from the lamp performance of a dragon, phoenix and lion in the Taishun Hundred-family Feast culture. It applies the unique colour scheme and structural form of the lamp to the landscape miniature, simplifying and artistically expressing the form of the horse by using the three fixed colours of red, yellow and cyan. The colours are divided into different sections, with the cyan part being played by people, from which the horse forms are extracted and replaced through the cyan glass (as shown in Figure 20).

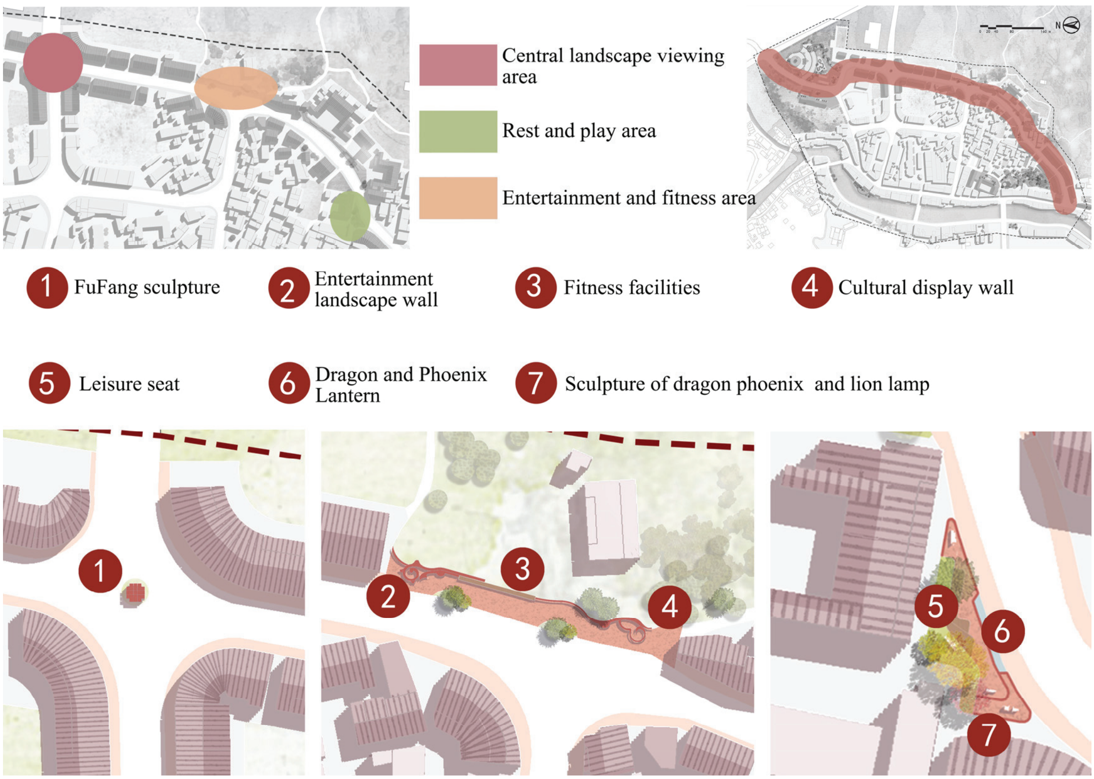


Figure 18. Plan of Hundred-family Feast culture district experience zone landscape.

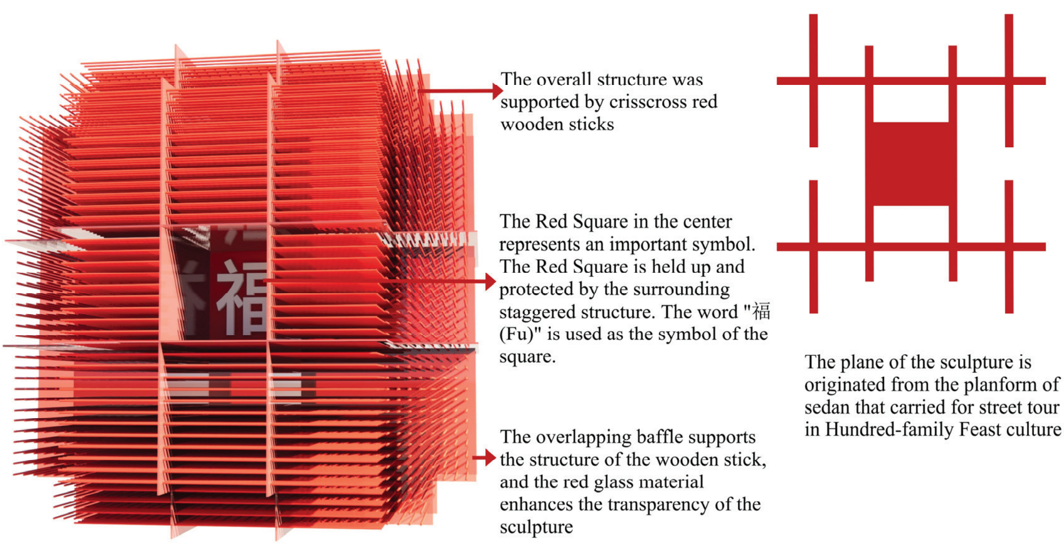


Figure 19. Fufang sculpture.

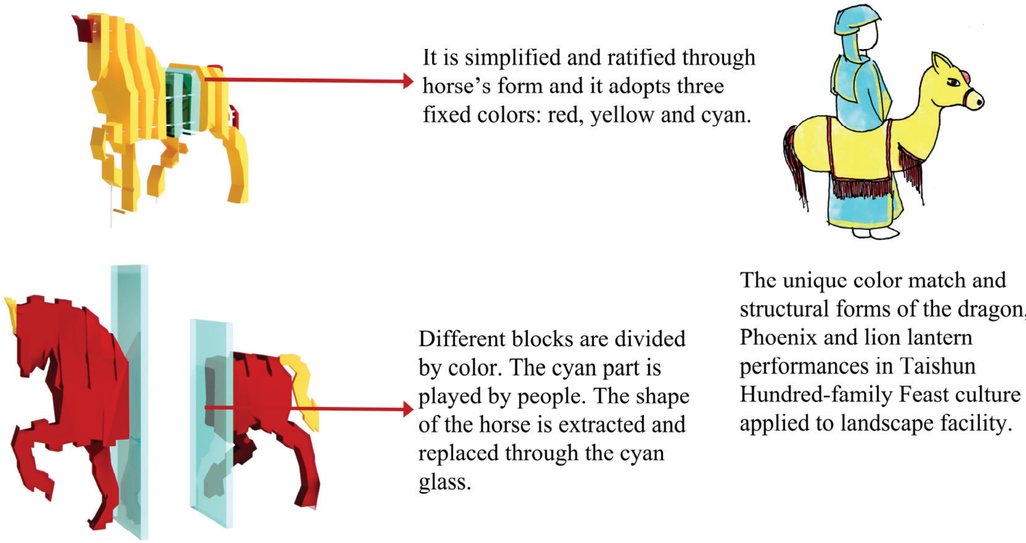


Figure 20. Dragon phoenix and lion lamp.

The landscape space of this zone is presented by the dragon, phoenix and lion lamp performance. The overall landscape is built around this theme, both in terms of colour and form, and is integrated with the landscape in a more straightforward and more explicit form, with the sculpture plaza space, resting and viewing space and water play space combined. The sculptures of different forms of dragon phoenix and lion lamps attract people to participate in them, shuttling between the sculptures to take photos. People can also watch, wait and rest through the resting space on the side, and there are some dragon and phoenix lights on the water in front of the square, as well as several small springs for people to play in (as illustrated in Figure 21).

Figure 21. Dragon and phoenix lion lamp culture landscape space.

3.3.8. The Landscape of the Leisure Tour Experience Zone

The leisure tour experience landscape is mainly divided into three parts. The first is the viewing area located on the west bank of Sankui Creek, while the second is the water-friendly activity area located on the east bank of Sankui. These two landscapes are opposite each other across the bank, and the third is the leisure and entertainment area located on the south side of the west bank of Sankui Creek (as shown in Figure 22). The viewing area shows the fireworks in Taishun's Hundred-family Feast culture. Through the water-friendly activity area, not only locals but also tourists can enjoy the scenery on the opposite bank and get closer to the stream; through the recreation area, people can watch the scenery and play simultaneously, which indicates the leisure function on tourists [32,33].

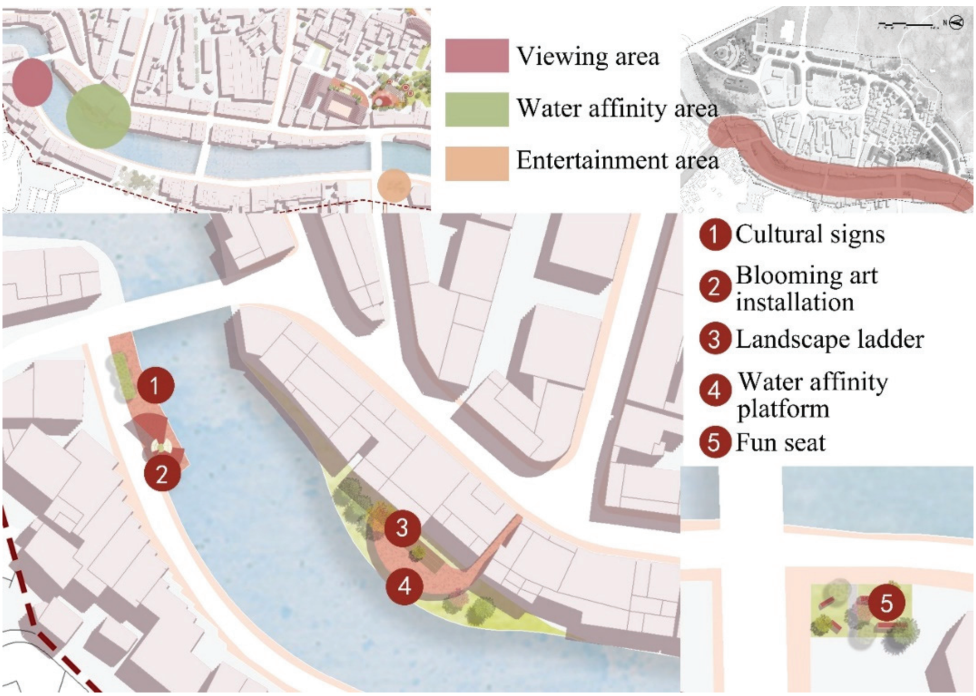


Figure 22. Plan of Leisure tour experience zone landscape.

The blossoming art installation as the landscape element carrier is enlightened by the firework display, which is the last element of the Taishun Hundred-family Feast culture. The blossoming form of the firework display is applied to the art installation, taking a point as the starting point and extending it in different directions with different gestures to show the beauty of the blossoming fireworks. The colours of red and yellow are used as the representative. The blossoming art installation is connected with the resting seats to form a sheltered space, which not only enhances the ornamental aspect but also facilitates people's daily rest (as illustrated in Figure 23). The space along the Sankui stream is mainly for natural scenery viewing. The whole landscape space is relaxed and leisurely. Compared to other landscape spaces, there is no lively activity space but more of a resting space to meet the needs of walking and resting by the stream. Along the Sankui stream, visitors can experience a different landscape space, either sitting quietly and enjoying the scenery, getting closer to the water and viewing the beautiful scenery on the opposite bank or playing in the broader area close to the stream.

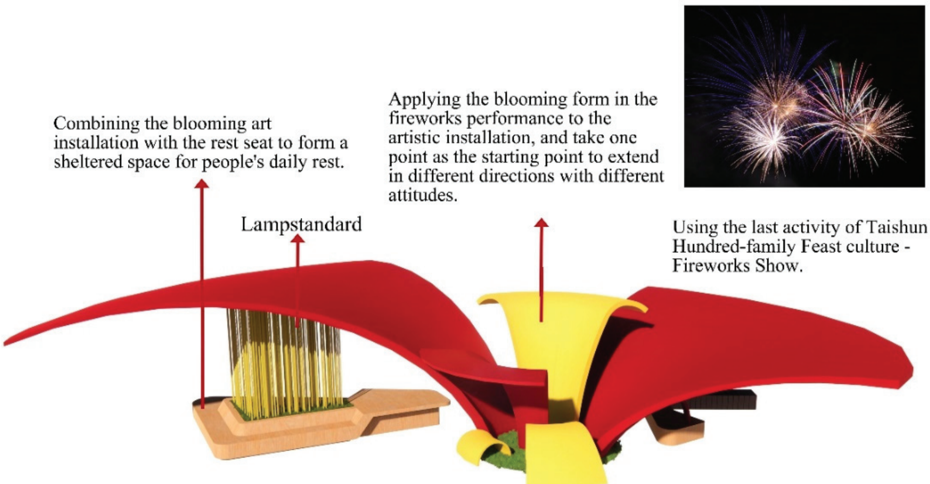


Figure 23. Blooming art installation.

4. Conclusions

The protection, development and transmission of intangible cultural heritage is an issue of great concern to society. For the wide variety of intangible cultural heritage, it is more meaningful to classify it into special studies [34]. This study applies the method of landscape presentation of the intangible cultural heritage of folk activities to the case study of the Taishun Hundred-family Feast culture. Through the in-depth excavation of the Taishun Hundred-family Feast culture, the excavation results are classified and analysed, the type of landscape space required for each cultural activity is analysed, and the pattern form, colour, material and text content of the material carrier of the cultural activity are analysed to extract the landscape design and apply it to the landscape structures and the complex expression of the landscape while making full use of the local natural resources and characteristics to fully integrate the spiritual beliefs of culture into the landscape space, which is finally applied to the landscape planning and design of Sankui town centre. Thematic, immersive and interactive landscapes are used to realize the cultural presentation of the Taishun Hundred-family Feast. For each thematic landscape area, different landscape elements and landscape spaces are used as the carrier for the construction of the cultural landscape of the Hundred-family Feast. At the same time, the landscape space carries each activity of Taishun's Hundred-family Feast Culture, creating a different cultural atmosphere and expressing different spiritual beliefs, thus attracting people to participate to feel and experience the Hundred-family Feast Culture. This also provides new ideas for protecting and developing the intangible cultural heritage and its inheritance. At the same time, it gives and enriches the cultural connotation of the landscape, achieving a mutual promotion effect.

Given the intangible characteristics of the intangible cultural heritage, it is necessary to rely on the expression of material carriers to achieve dissemination and development. Moreover, it is closely linked to the surrounding natural and cultural environment. Hence, the protection of intangible cultural heritage through landscape presentation is more conducive to the dissemination and development of intangible cultural heritage. This paper presents a three-step approach to the landscape presentation of the intangible cultural heritage of folklore activities through content excavation–extraction of landscape design elements and landscape expression, which can effectively explore the landscape expression of this type of heritage and achieve more targeted protection and development of intangible cultural heritage.

At the same time, the landscape presentation of the intangible cultural heritage of folklore activities is complex and contains a great deal of content. Therefore, it is necessary to further explore the dependency relationship between the intangible cultural heritage of folklore activities and the landscape carrier and to follow up and investigate the protection and transmission of intangible cultural heritage and people's experience during the development of the relevant cases from the actual effect of the landscape presentation, to verify and improve the theory in the long term.

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Appendix A

The four cultural themes excavated from the Taishun Hundred-family Feast Intangible Cultural Heritage regarding the activities and cultural beliefs.

(1) Ritual culture

The ritual culture concentrates on the spiritual beliefs of the local people in their ancestors, the Fourteenth Goddess of Chen and Wang Qilao. It includes the spring ritual at the ancestral shrine in the morning, the ritual ceremony for the Fourteenth Goddess of Chen at Linshui Palace in the afternoon, and the street tour activities in the street parade. The material carriers of these include bamboo sticks with bamboo leaves, firecrackers, ritual chants, tributes, dressing for the parade and palanquin, all of which can be used as landscape elements. The rituals of the spring festival are more solemn, while the street strolling activities are more lively and active. Both revolve around a specific cultural space, and when creating the atmosphere for the two different activities, they should be combined with their characteristics to create their landscape atmosphere. The whole process of the event is possible to perceive and learn the cultural and spiritual connotations through words, patterns, statues and virtual images in the experience.

(2) Food culture

The food culture reflects the unique agricultural products, cooking techniques and gourmet recipes of the local people. The food culture in the Hundred-family Feast culture has a more spiritual connotation given to the food:the symbolic meaning of the dishes. The preparation work before preparing the banquet also has a unique connotation in the Hundred-family Feast culture. These include the preparation of the banquet, such as the drawing of the lucky head in the year of the flower row, the raising of the fortune money and the setting up of the venue, the origin of the names of the dishes, the ingredients needed for the dishes and the preparation process of the dishes in the Hundred-family Feast dishes.

(3) Festival culture

Festival culture can reflect the various activities performed by local people to celebrate events, including dragon and lion dances, dragon and phoenix lion lamps, folk music performances, pyrotechnic puppets, puppet shows and fireworks displays. The colours and styles of the dragon and lion dances and lion lanterns can be extracted to express the landscape, using the colours of the landscape elements and materials. Folk music can be expressed through musical instruments and the melody of the music, enriching the landscape experience through the sound of the instruments. The pyrotechnic puppets and puppet shows can be used to show and educate people by dissecting the principles involved in the form of landscape installations and by using the figures of the dolls to present local stories. Firework displays can be created with different patterns to create a unique and culturally relevant firework.

(4) Spiritual culture

Spiritual culture is concentrated in other cultures and contains the spirit of commemorating ancestors, praying for a good harvest, blessing peace, harmony and unity. These spiritual cultures are inseparable from any activity in the Hundred-family Feast culture; therefore, in the process of presenting it, these spiritual cultures should be integrated into the landscape in every detail. The most representative features are "red", "lanterns", "fortune" and "circle" patterns, and these elements are used as the main landscape elements to create a spiritual space.

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Article

Students' Awareness of the Local Cultural and Historical Heritage in Post-Communist Regional Centers: Yekaterinburg, Gyumri, Timisoara

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Abstract: The article presents an analysis of students' awareness of the local cultural and historical heritage in post-communist countries, taking the examples of Yekaterinburg (Russia), Gyumri (Armenia), and Timisoara (Romania). A multidisciplinary methodology was applied, including a sociological survey, visualization of city places, and assessment of the respondents' capacity to engage with the identified historical and cultural items. The provided data visualizations demonstrated the preferences of young people for certain spaces, and allowed assessment of young people's awareness of selected instances of historical and cultural heritage. An attempt was made to estimate critically how historical and cultural objects are included in youth consciousness. An attractive image of the city and its positive perception can be used as a basis for engaging youth participation in the development and promotion of the city. Results can be useful for city managers and administrators, to promote better engagement with this age group and its involvement in promoting the city brand and in place production.

Keywords: historical and cultural heritage; regional center; youth; place production

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1. Introduction

Scientific research on the preservation and actualization of historical and cultural heritage is retrospective, as a rule, for understandable reasons. Historians are concerned with the recreation of a period, accuracy of data, and the reliability of sources, links between data, and personalized information. Scholars of cultural studies typically explore the uses of heritage and the meaning of its cultural forms to interpret the present and the past. Heritage, however, deals not only with the past. It is constantly re-assessed, re-considered, and re-interpreted, endowed with new values and meanings [1]. As defined by UNESCO's World Heritage Center, cultural heritage "is the legacy of physical artefacts and intangible attributes of a group or society that are inherited from the past generation, maintained in the present and bestowed for the benefit of future generations" [2]. UNESCO further develops that idea in the Memorandum on "World Heritage and Contemporary Architecture" [3], stating that "historic areas and their surroundings should be regarded as forming an irreplaceable universal heritage", and urging "governments and the citizens of the States in whose territory they are situated (. . .) to safeguard this heritage and integrate it into the social life of our times". Heritage is a prerequisite for consideration in the development strategy of a place, integrating its qualitative characteristics in the direction of preserving the uniqueness and identity of the past, while maintaining stability and ensuring the productivity of that place. Places of considerable historical significance still need to live and allow development, otherwise they may become endangered and lose their chance of a future. The major crises of the 21st century, first the economic one in 2008 and more recently the health crisis triggered by the COVID-19 pandemic, opened new perspectives for viewing historical heritage. Therefore, this research aims to explore how stated preferences of youth retain and value places and spaces in cities of choice for pursuing higher education.

National capital cities usually receive particular attention, due to their international exposure, significant budgets, and privileged situations, and traditionally have harbored the main centers of power in political, financial, cultural, and symbolic terms. Other cities, however, need skilled effort to gain a place on the world map. Regional centers, which are the focus of this study, must find ways to be competitive, visible, and efficient in pursuing their development and branding goals, using less resources than capital cities and relying on more innovative solutions. This research team selected regional centers of three post-communist states—cities where universities are concentrated, which attract young people from all over the region—aiming to identify how the younger generation perceives the attractiveness and unique features pertaining to these cities, to illustrate with examples awareness of the valuation of different cultural goods, and to identify how this generational group is ready to engage in cultural and economic strategies rooted in local cultural and historical heritage.

Several issues are specific to the selected type of cities. First, to preserve themselves and secure their sustainable development, cities that are regional centers have sought to retain young people through a variety of means, including cultural policies, often at the expense of nearby smaller settlements [4–7]. Second, in a more difficult situation, international experience shows that the involvement of young people in urban development projects brings significant gains in terms of cost-reduction and, even more importantly, in attracting residents to the place, leading them away from alienated indifference [4,8,9]. Third, the urban landscape, including historical objects and spaces, can be built while considering the social activities, patterns of behavior, and trajectories of young people, on which consideration the choice of new functions and new meanings of historical and cultural objects and public spaces depends [2,8,10].

Each generation brings its unique understanding of physical, social, economic, political environments [11–13]. The current generation of young people, typically referred to as "Generation Z", is described as globally focused, digitally socialized, and overwhelmingly visually engaged [11,12]. The study of their movement patterns around the city can benefit from an approach bringing together sociologists and specialists in visual technologies. Such research can take place when using visual models of urban space, since 21st-century architects actively use possibilities of information technology (IT) in search for new architectural forms, thereby proposing new approaches in design and construction, in line with UNESCO's recommendations on architectural interventions in historical sites [3].

The questions addressed by our research were: Q1: What architectural spaces or historical–cultural (historical–architectural) objects are retained by young people and shape their (positive) perception of the city?

Q2: Are these spaces or objects integrated in the places students prefer for gathering and socializing?

2. Literature Review

Scholars in a variety of disciplines have explored the issues of urban landscapes, cultural heritage, and identity, focusing on different aspects. Understanding the city as an individualized place of intersection of territorial settlement, socio-communal, and mental structures [3,5], we assign decisive importance to the latter. In search of an appropriate frame for analyzing the contemporary city, its heritage, and residents' engagement with the space, this research team builds on works relating to the sociology of the city [14] that allow the city and its citizens to be considered in a single research plane, without reducing the first exclusively to the totality of architecture and infrastructure. Park, for example, wrote that Chicago is "something more than a collection of individuals and amenities... The city is rather a mindset, a body of customs and traditions . . . , a product of nature, especially of human nature" [14] (p. 1). Culture, in such an interpretation, is the fourth and final factor in the social organization of citizens and at the same time represents their competition. The city "comes to life" and receives individuality, due to the actions and faces of citizens [8,9,15,16]. At the other end of the spectrum, super-modernity produces "non-places" inside places, i.e. areas in which habitual relational and social purposes are lost, the free movement of individuals is supervised and, at times, regulated and channeled, and identity is diluted. In his seminal work, *Modernity at Large*, Appadurai discussed the need to "produce locality" as a contextual and relational outcome of the effort to maintain a sense of place in the flow of globalization [17]. Groups and individuals need to apply the notions and resources of heritage and memory in confirming identity and reducing uncertainties enhanced by globalization. This is a ritual process, and a deliberate act of production, involving local knowledge, local subjects, and physical objects existing in the geographic space. He warns that "without reliably local subjects, the construction of a local terrain of habitation, production, and moral security would have no interests attached to it" [17] (p. 181). For him, locality is an ever-changing construct that emerges from the practices of local subjects in specific neighborhoods. The possibilities of its realization as a structure of feeling are, in this respect, as variable and incomplete as the relationships among neighborhoods that constitute its practical instances [17] (p. 199).

Along similar lines, Augé discussed the results of place production practices leading to the place–non-place dichotomy [18]. Augé cautions against the romantic vision of places, seen in traditional anthropology as timeless, unchanging, "rooted in the intact soil", maintained by archaic and exotic indigenous rituals, with reference to the "totality temptation" according to which culture is imagined as holistic and accurately represented by randomly selected individuals, artifacts, places, and practices. While localities (places) come to existence by virtue of being relational, deeply historical, and intimately connected with social and individual identities, non-places are transitory places, which human actors pass through as anonymous individuals and do not relate to or identify with in any intimate sense. Airport terminals, hospitals, movie theaters, and shopping malls are some of the most salient examples of such public spaces, where social action does not take place, residues from human practices do not accumulate, and concrete and artificial surfaces tend to dominate. However, the field research carried out to analyze the selected cases for this study was able to identify both "places" and "non-places" recalled by respondents in their descriptions of the cityscape.

As far as the post-socialist features of the cities selected for the analysis, it is important to refer to Diener and Hagen's analysis of the entanglements of ideology and identity in the urban landscape of (post)socialist cities [19]. According to their research, the socialist period laid a strong mark on urban landscapes, entire cities being seen as "symbolic texts that reflected social, economic, and political relationships of power and resistance though their aesthetics, function, layout, and scale" [19] (pp. 490–491). Post-socialist urbanism, evolving in the context of globalization, supranational cooperation, and cultural hybridity, invites new narratives of the urban landscape, where local identities co-exist with broader global ones associated with modernity, transparency, and progressivity. Such new narratives, however, can lead to conflicting interpretations [1], especially for places and city objects that bear heavy political loads.

The main concepts underlying the above-mentioned literature are culture, heritage, and identity. Traditionally, this triangle was assumed to be the foundation of societies [20] and although some parts of this model may be subjected to critical scrutiny, it still lies at the core of most research and even policy development, especially in the field of soft power. Cultural policy is increasingly used as a tool of soft power in a geopolitical sense. Countries, and also sub-national-level subjects such as regions or cities, resort to cultural policy to wield soft power based on attraction, created by policies and opportunities of the country (or region, or city). From this point of view, cultural–political factors, such as sustainability, authenticity, inclusiveness, networks, and economic effect are considered strategic components that play a significant role in defining place identity and enabling all stakeholders to organize around shared cultural values and vision [4,9]. Hence, specific instances of such soft power potential were considered in the cities selected for analysis by this research. In addition, the identified objects or spaces were presented in a visual form, to allow for qualitative analysis.

The visualization of data allows accurate assessment of preferences and degrees of development in urban spaces, putting historical and cultural heritage in the perspective of its inclusion in the field of visibility and activity of young people. The visual representation of certain places of the city is realized in this study in accordance with the position set out in the work of Lynch, objectifying the understanding of the image of the city as a set of object–spatial elements by which a person correlates themselves [21]. The introduction of this information into scientific discourse is legitimized by Latour's theory [22]. The transition to the study of urban and everyday culture based on the analysis of images occurs in the works of Bachmann-Medick with her concept of performative and visual turn in culture [23], and the work of Mitchell [24]. The researchers authoring this current study consider that the respondents' attitudes towards the cities are an indicator of the cities viability.

Pirogov identified four grounds for the sociological typology of attitudes to the city. These include a motivational basis associated with the need for self-realization, which acquires special features in cities of different states and scales and determines the value orientations of a person; a dispositional basis as a system of attitudes in relation to perceptions of the city; an intentional basis that specifies personally significant objects to which human activity is directed; and a subcultural basis that determines the attitudes to the city of people of different social groups [25]. Accordingly, underestimation or misunderstanding of certain objects or of the whole city is fraught not only with passivity, but also with all sorts of negative actions, from vandalism to departure [4].

Attitudes towards the city depend significantly on its manifestation of a "human scale" [26]. This scale involves physical and visual spaces commensurate with the person and the possibilities of their perception, including the presence of many pedestrians (not cars), greenery, and visual landmarks. Furthermore, attitudes towards the city are not static. They can change during different cultural practices, as highlighted above [1]. To involve young people in urban development and promotion, it is necessary to understand their readiness for action, their degree of attachment to a place, and so on. Research results capitalize on the responses of a generation that might not have the actual power to determine change [12], but whose presence ensures the viability of the investigated cities and their capacity to maintain relevance on a regional, national, and even global scale [8].

3. Materials and Methods

3.1. Research Methodology

To achieve a balance between empirical data and theoretical constructs, we included as main components in the methodology a sociological survey, the visualization of urban areas, and axiology, which gives priority to explaining people's actions through the lenses of their attachment to certain value attitude; in our case, attitudes towards historical and cultural objects and urban spaces.

The survey was conducted in the form of an online questionnaire. The questions were open-ended, respondents being invited to freely nominate places in the city that they find interesting to show or describe to visitors or friends, and places they prefer for their leisure time activities. In each case, respondents were asked to indicate whether they are indigenous, newcomers, or in temporary residence in the city, and their degree of familiarity with local history and heritage. No incentives were used to attract participation in the survey. The link to the questionnaire was proactively placed in thematic groups in young peoples' social networks, uniting students from different cities and universities. Data were collected in a manner ensuring the anonymity of respondents. Hallmarks identified by respondents to the questionnaire were visualized on maps and explored from the point of view of their historical and cultural load. Conclusions were drawn from the results from an axiological perspective.

3.2. The Sample

During the study, 1013 respondents self-reported their opinions by answering the online questionnaire dedicated to collecting the views of young people regarding their awareness of the history and culture of their cities, to assess the experience of social participation of young people, and the readiness of young people to join "direct actors" or engage independently in various practices. The sample was targeted to include student youth of universities in regional cities in the compared countries: Yekaterinburg (Russia, N = 465), Gyumri (Armenia, N = 268), and Timisoara (Romania, N = 279). Russian, Romanian, and Armenian variants of the questionnaire were distributed. Responses are discussed for each country, and in a comparative perspective.

3.3. The Cities

The present article discusses the data obtained via a sociological survey carried out in three regional capitals in three post-communist countries: Yekaterinburg, the center of the Sverdlovsk region (Russia); Timisoara, the administrative center of the county Timis (Romania); and Gyumri, the regional center of the Shirak region (Armenia). The choice of survey regions in the declared countries was motivated by several characteristics:

- The cities share a common cultural and historical background, associated with their socialist past.
- They fulfill similar functions in their respective regions (economic, administrative, cultural life criteria)
- These cities attract young people from their respective regions for studying at respectable universities, the presence of skilled labor being a pre-condition for ensuring the sustainable development of a city or region.

Otherwise, these cities have very different histories and different cultural landmarks. They were each established in different historical periods, information about which remains apparent in their layout and mentality.

The million-plus city of Yekaterinburg in the Urals in Russia is a classic "factory city"—an industrial settlement, one of many created in the 18th century [27]. Founded in 1723 on the small Iset River as a fortress city, and forced to defend itself from raids by the local Tatar and Bashkir population, this city has a compact regular structure, and a high density of buildings, which was expanded in later periods. The center of Yekaterinburg, once a production centre, is today a post-industrial place, with sports and cultural facilities, administrative buildings, and public spaces. The architecture of earlier periods has rapidly been absorbed by office and residential skyscrapers, and the visual environment of the city is chaotic and eclectic, although initially it had many architectural ensembles.

Gyumri was founded in the 8th century BC, in the area that is now Armenia. Throughout its history it has experienced many influences and renaming initiatives, and withstood the earthquakes of 1988 and 1998. According to the 2007 census, the population of the city was 147 thousand people. However, the population is decreasing, primarily due to economic reasons. The city lies in a valley with a slight slope, surrounded by mountains. In the middle of the 20th century, it was a center for mechanical engineering, the textile industry, and food production, which suffered greatly after the collapse of the USSR in 1991. Currently none of those enterprises are functioning, and the city is not under continued construction. The buildings destroyed in the last earthquake have not been restored, and housing stock has not expanded. The development of the city center can be characterized as "regular vernacular" and displaying "freedom inside the grid" [28]. Planned quarters of low-level buildings were created by local master masons, almost without the participation of professional architects, and today continue to serve as an urban center. The city has retained its authenticity, has a high degree of recognition, and its environment is aesthetic.

The third biggest city in Romania by population, Timisoara is the historical center of the Banat region and the administrative center of Timis County. It lies in the west of the country, close to the border with Serbia and Hungary. The area of the city is 130.5 km^2, its population is more than 300 thousand people. The first settlement dates to 1019, but the city was created at the beginning of the 13th century as a fortress. The fortress passed from Hungarian to Turkish and later to Austrian rule. It has flourished as a cultural centre and university city since 1919, when the Banat region entered the componence of Romania. For 2021, Timisoara was selected to be one of the European Capitals of Culture [29], however, the COVID-19 pandemic has shifted the planned cultural events to 2023. In the center of the city was previously a citadel surrounded by a canal. At the end of the 19th century, during the expansion of the city, most of the old defensive wall was demolished. The canal turned from part of the city's defensive system into an element of its transport system, connecting different parts of the city, and the city itself with Europe.

While the cultural and historical heritage of these cities may be itself a topic of interest, the present study analyzes only those landmarks that appear in the memory and active life of young people, thus exposing the link between the past, present, and possible future of the city through the lenses of students' experiences and memories. The collection of data was carried out in March–May 2021, when students were studying remotely, due to COVID-19 restrictions. Therefore, they had to recollect their places of interest and preferred places for gathering, using experiences or knowledge accumulated before the disruption brought by the pandemic [30].

4. Results

This section builds upon the results of the survey and socio-cultural assessment of urban spaces, presented in the order indicated by city selection. It unfolds responses to various questions: What architectural spaces or historical–cultural (historical–architectural) objects are retained by young people; what load of stories, legacies, or functions the identified tangible objects carry; which places students find attractive for gathering and spending leisure time.

The research focuses on the intentional component that determines the specifics of reference of the city and its objects. Judgments such as "In the city it is important for me ... " or "This city is for me ... " set the direction of activity. Students were asked to freely nominate the architectural objects and spaces they felt familiar with, proud of, and worthy of showing to potential city visitors. The research team retained a list for analysis, based on the frequency of appearances in the responses. Nominations are presented in the larger context of historical information, with geographic coordinates, accounting for the "local knowledge" that, even if subconscious, influences young people' image of the city, forming a positive perception, and causing the interaction of students with the nominated places.

4.1. The Historical-Cultural and Historical-Architectural Heritage of Yekaterinburg

The results of the survey indicate that young people listed eight objects among the places most beautiful and worthy of special attention in Yekaterinburg, which included seven buildings and one square, all in the city center, on its main streets (Figure 1).

The objects identified by respondents to the survey are not connected by transportation routes. They do not determine the trajectories of movement and activity of youth communities within them, thus do not overlap with the patterns of movement of youth around the city. Nevertheless, they set a specific visual framework for the central part of Yekaterinburg. The buildings include the residence of the President of the Russian Federation, as well as the former house of Sevastyanov, the Vysotsky skyscraper, and the city administration building.

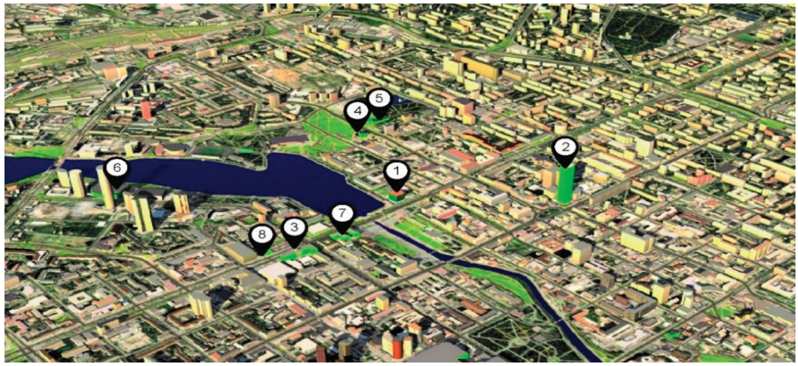

Figure 1. Visual model of Yekaterinburg with an indication of buildings that young people find attractive and interesting.

The Sevastyanov house is an object of cultural heritage with federal significance. It is a vivid example of the eclectic neo-Gothic style of the second half of the 19th century (reconstruction in 2009, UralNIIproekt under the leadership of A. V. Dolgov). The building is on the main street of Yekaterinburg, next to the dam from which the city planting began. Part of the embankment is contained within the architecturally organized space in front of the object, where there are viewpoints and places of leisure, from which a beautiful view opens onto the building itself, the pond, and several architectural objects of different periods. The attractiveness of the Sevastyanov house lies in its unusual appearance, combined with its location that allows one to be inspired and to appreciate the beauty of this object of architectural heritage erected at the end of the 19th century.

Second on the list was one of the tallest buildings in Yekaterinburg—the Vysotsky skyscraper (2011, architects A. Gavrilovsky, V. Grachev). Its modern style has several features, ranging from the atypical height for Yekaterinburg to an interesting composition, including external glazing. The entrance area is reserved for parking, not leaving room for recreation.

Third was the building of the city Duma (city administration), also located in the city center. Designed by architect G. A. Golubev as a constructivist building, it was refurbished in 1954 in the Stalinist Empire style. The entrance in the arched niche is decorated with a monument panel made in the sgraffito technique on the theme "Salute to Victory". In front there is a small round platform with benches.

The marked figures are explained below, the numbers reflecting the order of nominations for the given place in the students' responses. The answers to the question "What historical building in your city do you consider the most beautiful, deserving of special attention?" scored as follows:

1. House of N. I. Sevastyanov (architect A. I. Paduchev, year of construction 1860)—20 nominations.
2. Skyscraper "Vysotsky" (architects V. Y. Grachev and A. Gavrilovsky, year of construction 2011)—11 nominations.
3. The city administration (city Duma) building (architects G. A. Golubev and M. V. Reisher, year of construction 1954)—eight nominations.
4. Temple on the Blood (Temple Monument on the Blood in the Name of All Saints, Shining in the Land of Russia) (architects G.V. Mazayev, Likina I.D., Morozov V.P., Efremov V.P., Grachev V.Yu. year of construction 2003)—five nominations.
5. Rastorguev–Kharitonov Estate (Kharitonov House) (architect M. P. Malakhov, year of construction 1824)—five nominations.
6. Presidential Center of B. N. Yeltsin (Yeltsin Center) (architect B. Bernasconi, year of construction 2015)—four nominations.

7. College named after I. I. Polzunov (arch. I. A. Grushenko, year of construction 1954)—four nominations.
8. The Square of 1905 (founded in the 18th century, acquired its modern appearance in 1957)—four nominations.

Commenting on the differences in age, styles, functional purpose of the objects chosen by students, we echo the urban sociologist Suttles who, in the 1990s, spoke about the "characterological unity of cultural representations" [31]. If the center is valuable due to its location, then the qualities of the objects outlining it play almost no role, and become simple markers of the territory.

While identifying mainly buildings as landmarks worthy of showing to potential visitors of the city, students preferred other places for gathering and spending leisure time. Squares, parks, and open spaces take the leadership in the latter category, and the respective maps do not necessarily overlap. Only three nominations were to be found in both lists (the lists of attractive or notable places and of places used for socializing and leisure time, respectively), i.e., the Yeltsin Center, the Temple on the Blood, and the Square of 1905. In Yekaterinburg the main places of attraction for youth are in the central part of the city—Plotinka (the place where the city was founded) and the Square of 1905—the main city square, as seen in Figure 2 below.

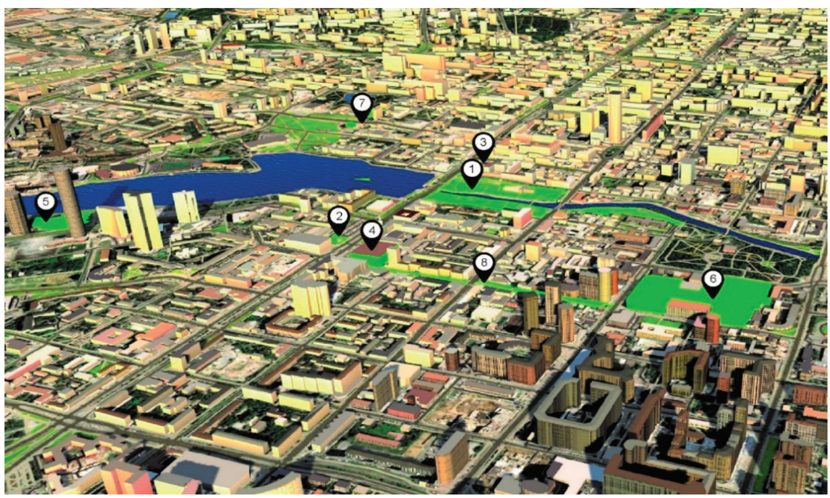

Figure 2. Visual model of Yekaterinburg with indication of places and spaces where young people gather.

The answers to the question "Near what places of your city do young people most often gather?" returned the following nominations:

1. Plotinka (founded 1723)—42 nominations.
2. The Square of 1905 (founded in the 18th century, acquired its modern appearance in 1957)—12 nominations.
3. Monument of Tatishchev and De Gennin (sculptor P. P. Chusovitin, year of opening 1998)—seven nominations.
4. Passage (architect V.V. Hromada, year of construction 2015)—five nominations.
5. Presidential Center of B. N. Yeltsin (Yeltsin Center) (architect B. Bernasconi, year of construction 2015)—five nominations.
6. SEC Greenwich (architect V.V. Hromada, year of construction 2004)—four nominations.
7. Temple on the Blood (Temple Monument on the Blood in the Name of All Saints, Shining in the Land of Russia) (architects G.V. Mazayev, Likina I.D., Morozov V.P., Efremov V.P., Grachev V.Yu, year of construction—2003)—three nominations.
8. Weiner Street (formerly Uspenskaya Street, renamed in 1919)—three nominations.

Plotinka and the Historical Square located next to it are favorite places for rest and walks for most citizens, and provide a venue for events of urban scale. The attitude towards the architecture of the place is not unanimous. Conservators emphasize the destructive nature of the works for repurposing the factory that historically attracted settlers to Yekaterinburg. Some parts have been demolished, others that remain currently host museums. However, the repurposed space is actively used by citizens and acknowledged by young people [27].

Second on the list by frequency of mentions is the Square of 1905, the city's central square. In a previous study of markers of urban identity, it also appeared as one of the most mentioned: "The younger generation singled out as a symbol of Yekaterinburg the central square of the city—the Square of 1905 (56.0%)" [32]. It can be noted that the area is relatively small, surrounded by proportional buildings, and free from the spirit of gigantism sometimes characteristic of the central squares of Soviet cities.

Consistent with the data of other urban researchers [7,10], the list of attractors includes mainly designated places that provide opportunities for meeting in large groups, which are open and accessible at any time (except for shopping centers), located in the city center, and are uniquely identifiable within urban spaces. At the same time, these places represent increased intentionality; the building or territory merges with the space of relations to itself and to other people, and this in some cases is layered with the symbolism of the place (not always, but only if the audience is informed in due measure). Almost all the identified objects are included in lists of significant places for Yekaterinburg recommended to tourists by various sources on the Internet (bloggers, travelers, tourist portals) [33].

4.2. The Historical–Cultural and Historical–Architectural Heritage of Gyumri

The survey carried out in Gyumri revealed eight places that, according to young people, deserve special attention of citizens and guests of the city. Among these were a church, a square, one memorial complex, a park, a theater, a city hall, and a museum (Figure 3).

Figure 3. Visual model of Gyumri with an indication of buildings that young people find attractive and interesting.

Responses to the question "What historical building in your city do you consider the most beautiful, deserving of special attention?" indicated the following preferences:

1. Black Fortress (built in 1834)—18 nominations
2. Seven-Sorrows Church of the Blessed Virgin Mary (year of construction 1887)—13 nominations
3. Kumayri (Kumayr Museum Reserve) (built 1860 to 1920)—13 nominations
4. Gyumri State Drama Theatre (year of foundation 1929)—nine nominations

5. City Hall Building (Gyumri Municipality) (architect G. Kochar, year of construction 1933)—six nominations
6. House Museum of the Dzitokhtsian Family (built in 1872)—five nominations
7. Vardanants Square (architect. A. Tamanyan, built in the 1930s)—three nominations
8. Memorial complex “Mother Armenia”(A. Sargsyan, E. Vardanyan, R. Egoyan, erected in 1975)—two nominations.

The Black Fortress is a round-shaped fortification built in the middle of the 19th century, after the end of the war between Russia and Turkey. It features among the main architectural highlights of Gyumri. The fortress is a short distance from the city center, and is currently under reconstruction with the intent to create a museum space. From the side of the fortress there are panoramic views of the city and its surroundings. Inside the fortress there is a large room where entertainment events are held privately, including events for young people.

The church mentioned in the survey was built in 1882–1887 on the site of the chapel where the icon “Seven Sorrows of the Holy Virgin” was kept. The building of this Catholic Church is constructed of processed black tuff, and is located in Vardanants Square, the central square of the city. The central location and the presence of a square in front of the church, with places for leisure and a fountain, allows residents and visitors to appreciate the architecture of this object.

The buildings in the open-air architectural reserve “Kumayri” reflect the spirit of old Gyumri, and are of Armenian architecture. Today Kumayri includes about 1100 monuments of national architecture, some of which are known from the films of A. Mkrtchyan. They are well structured; their décor includes different levels of scale and is devoid of monotony. Such objects, according to video ecology, favorably affect all people without exception since they are devoid of aggression [34] (p. 25). In addition, the unique historical and architectural environment of the place largely determines the identity of the city, including its authentic quarters, which are well preserved and harmonious. All the objects selected by students are described in information material for tourists and are included in lists of significant places to visit in the city, according to various Internet guides and tourist resources [35].

The list of places where young people gather revealed two obvious leaders, i.e., Vardanants Square and Theater Square. However, shortcomings in the field of symbolic economy can be identified, since the historical and architectural potential of the place has not been fully put to value. It is no coincidence that the American city researcher Zukin noted that, “by the combination of architectural motifs, culture plays a key role in the redevelopment strategy, which is based on the idea of preserving the local historical heritage” [16] (p. 17). The results of this youth survey can serve as an additional argument in favor of working with the historical and architectural heritage of Gyumri. All the objects selected by students are presented in information materials for tourists and are included in lists of significant places to visit in the city, according to various Internet guides and tourist resources. Vardanants Square is the central square of the city, near which are located six of the eight cultural and historical objects selected by respondents. It is in this urban space that the city’s main cultural events take place, and citizens gather for fairs, rallies, or holidays. In our view, the opinions of students about centers of attraction for young people in their city were largely determined by the central location of this meeting place for citizens for various situational recreational practices, as indicated in Figure 4.

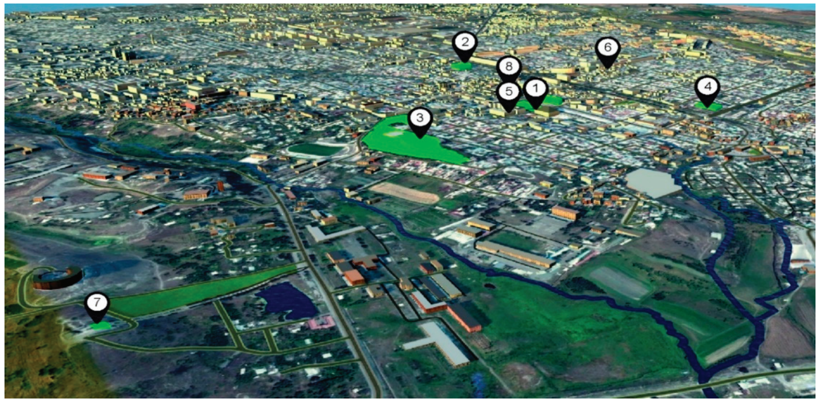

Figure 4. Visual model of Gyumri with indication of places and spaces where young people gather.

In general, the question "Near which sights of your city do young people gather more often?" received the following answers in Gyumri:

1. Vardanants Square (architect A. Tamanyan, built in the 1930s)—54 nominations.
2. Theatre Square (opened 1928)—30 nominations.
3. The Park (Central City Park of Gyumri named after Maxim Gorky) (opened in the 1880s)—four nominations.
4. House Museum of the Dzitokhtsian Family (built in 1872)—three nominations.
5. Ryzhkova Street (renamed after the earthquake of 1988)—three nominations.
6. Kumayri (Kumayr Museum-Reserve) (built 1860 to 1920)—three nominations.
7. Memorial complex "Mother Armenia"(sculptor A. Sargsyan, E. Vardanyan, arch. R. Egoyan, year of opening—1975)—two nominations.
8. Seven-Sorrows Church of the Blessed Virgin Mary (year of construction 1887)—two nominations

Five out of eight nominations overlapped between Gyumri students' preferences of most attractive buildings or places and places chosen for socializing: The Seven-Sorrows Church of the Blessed Virgin Mary, Kumayr Museum Reserve, Vardanants Square, Memorial complex "Mother Armenia", and the Gyumri Theater square. The two most frequently visited objects are open rectangular spaces, next to which there are places for recreation, a fountain, and a cafe. They are organized by enclosing buildings, and improved streets for pedestrian promenade. This is a habitable and at the same time open urban environment suitable for a traditional family holiday in Gyumri. Its frame is a low-rise building and mountains that do not obscure the visual perspectives of those who spend time in these favorite places. In the first square, ancient temples, coexist with buildings of the city administration, city cafes, and museums, as in many world cities. Also in the square there is one of the remaining operating cinemas, located in a building typical of cinemas in the Soviet period. The pedestrian street of Ryzhkov and the area of the Kumayri reserve are adjacent to it. The Theater Square, developed in the Soviet period and largely preserving the spirit of that era, cannot but be reflected in the minds of Gyumri youth. There exists a general love of the inhabitants of this city for theatrical art and the frequent practice of regular visits to the theater by the whole family. Student youth in Gyumri see themselves in landscaped spaces, spending time on those streets that have been improved to allow strolls, the meeting of company, and family activities. The organic urban environment, the connection of the central square with pedestrian streets, and the accessibility and proximity of the city park of the "Soviet period" allow the visitor to grasp the spirit of the city.

4.3. The Historical–Cultural and Historical–Architectural Heritage of Timisoara

Timisoara, Romania's third largest city, has a rich history. It began with a small fortress, which today is located in the historical center of the sprawling city. Respondents to the survey identified eight buildings (places) that young people consider to be the most beautiful in the city (Figure 5). Most of them, as in the two cities described above, are in the city center.

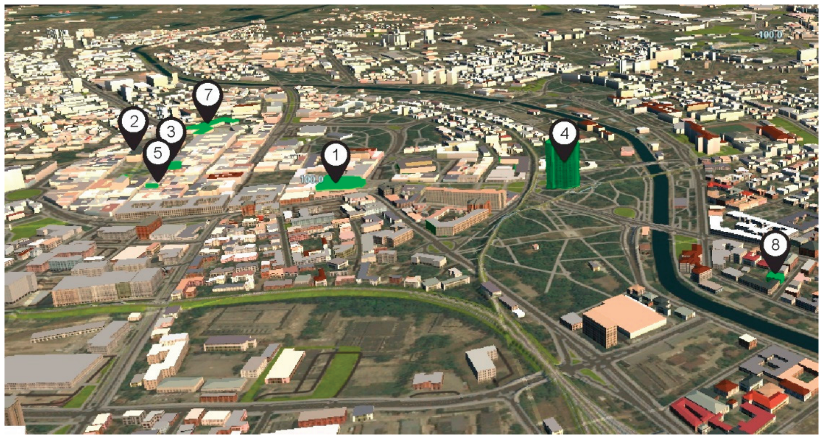

Figure 5. A visual model of Timisoara showing the buildings that young people find attractive and interesting.

In general, the question of which historical buildings in Timisoara people consider the most beautiful and deserving of special attention obtained the following nominations:

1. The Opera House (arch. G. Helmer and F. Fellner Jr., built between 1871 and 1875, reconstructed after a fire by architect D. Marcu, 1922–1928)—31 nominations.
2. The Roman Catholic Dome (also known as St. George's Cathedral) (designed by Joseph Emanuel Fischer von Erlach in 1736, finished by Johann Theodor Kostka and Carl Alexander Steinlein in 1774)—24 nominations.
3. The Metropolitan Orthodox Cathedral (Timisoara Cathedral of the Three Saints) (arch. And. Trajanescu, years of construction—1936–1946)—20 nominations.
4. Museum, Baroque Palace (built between 1725 and 1754 in the baroque style, renovated at the end of the 19th century, when some of the baroque elements on the façade were removed)—19 nominations.
5. Bruck House (arch. L. Szekely and A. Merbl, year of construction 1910, secession style)—seven nominations.
6. Water Tower (built between 1912 and 1914)—seven nominations.
7. Maria Theresa Bastion (built between 1732 and 1734, the largest preserved piece of defensive wall from the Austrian-Hungarian fortress of Timișoara)—four nominations.
8. Students' House of Culture (built in 1936 by arch. Michael Wolf in a style known as Wolf modernism. The building belongs to the Notre Dame complex and is currently under negotiations for restoration as a property of the Catholic church)—eight nominations.

The first place in terms of frequency of mentions was occupied by the Opera House, built more than a century and a half ago. The theater is in the center of the city, facing the facade of the main Orthodox church in Timisoara, the Cathedral of the Three Saints, which ranked third in the nominations. In between these two building lies Victoria Square (sometimes referred to as the Opera Square or the city center), mainly built in the historical secession style. The second most frequent mentions were for the Dome, located in the center of the "old town", which has been declared an architectural reservation of the baroque, being one of the latest European squares to be built in this style. In front of it lies a large square—Unirii Square. The square is a very open, pedestrian zone. Since the 1990s the local administration has designated it as the place for open-air cultural events. Its unique harmony and its preservation of the late baroque is evoked in the phrase "Timisoara—the little Vienna", often cited with pride by locals when describing the city. Fourth on the list is the Baroque Palace, in the same square. The palace, built as a royal residence, currently hosts the art museum, and also has a beautiful hall used as a venue for a variety of events including musical concerts and literary festivals. The Unirii Square also contains the beautiful Bruck House, described by local guides as resonating with Gaudi's architecture in Barcelona (Spain). The Water Tower is an industrial monument quite visible from most places in the city, particularly so since the water tram on the Bega River has been operational (2018). However, it most probably received attention because media have intensively promoted the city administration's initiative to turn it into small cultural cafe, a coffee museum dedicated to Francesco Illy (1892, Timisoara–1956, Trieste, Italy), the inventor of an espresso coffee machine that bears his name. However, this initiative has not been operationalized. The tower can be visited, but only upon special appointment as part of the Architectural Tour. The Students' House of Culture remains in the minds of young people as the residence of a literary circle, of the students' theater company, and of important student festivals, but very soon they will have to move such activities to other locations, because the building is part of the Catholic heritage. Finally, the Maria Theresa Bastion, named after the Austrian Empress Maria Theresa, covers about 1.7 hectares of the city center. Restored significantly in 2011, it houses the administrative corpus and exhibition areas of the Museum of Banat, the regional touristic information center, commercial spaces, restaurants, bars, a disco, and a library, and also allows passage between the square in front of the Bastion and other important areas of the city.

In the history of the city, the center moved from within the walls of the fortress (demolished in the second half of the 19th century, to make room for the rapidly expanding city) to Unirii Square, later to be moved again to the Victoriei Square. However, the three places are in near proximity, at 5-min walk from one another. Interesting to note is that only one respondent nominated Lloyd Palace (1910–1912, architect Leopold Baumhorn, secession style) as a place of importance, although the building hosts the Politehnica Rectorate, is situated in the proximity of the Opera, and is represented in many postcards and promotional materials [36]. Equally surprising is the fact that respondents did not nominate any of the post-Communist architectural projects, even though, for instance, Iulius Mall, a mixed-use development at the city edge, is one of the preferred places for shopping and leisure time [37].

While some of the nominations for Timisoara may seem surprising, the mentioned buildings and places received unexpected visibility during the pandemic. The Spotlight Heritage Timisoara project [36] has aimed to provide information and stories related to the landmarks of the city in digital and physical formats, in preparation for becoming a European Capital of Culture. Since 2019, it has actively shared via Facebook and other social media platforms stories regarding the history, architecture, social functions, and memoires attached to these historical neighborhoods. Within the framework of the project each featured building or place receives a plate with a description, the information being mirrored in the digital format. Applications of virtual reality have been developed, and in addition to photographs of the landmarks the project included the organization of three thematic exhibitions, involving communities sharing "my story" of the city. However, the heritage of the near past, i.e., the socialist period, while continuing to be evoked for historical events, is hardly represented overall.

In Timisoara, the question of the most visited places showed that the cultural and historical sites that determine the attractiveness and form the image of the city differ from places of youth activity. The survey singled out Unirii Square, the city center, and its parks, of which there are as many as seven, as highlighted in Figure 6.

Figure 6. Visual model of Timisoara with an indication of places and spaces where young people gather.

In general, in Timisoara the question "Near what sights of your city do young people most often gather?" received the following nominations:

1. Unirii Square (Dome Square) (18th century, redesigned in neo-baroque style by architect S. Sturdza in 1989)—28 nominations.
2. City Center (also nominated as Victoriei Square)—27 nominations.
3. Parks, i.e., the Botanical Garden (architect S. Grumeza, year of opening 1966), Rose Park (architects W. Muhle and W. F. Nimitz, year of opening 1891), Central Park (year of opening 1890), Cathedral Park (behind the Metropolitan Cathedral)—26 nominations.
4. The Opera House (arch. G. Helmer and F. Fellner, Jr., built between 1871 and 1875 years, architect D. Marcu reconstr. 1922–1928)—18 nominations.
5. Water Tower (built between 1912 and 1914)—seven nominations.
6. The Dome (1736–1774)—four nominations.

Except for the Water Tower, which was surprisingly nominated, since there is very little space around it for any type of gathering, the two nominated buildings, the Opera House and the Dome, are integrated in the larger urban spaces of the preferred squares, with many cafeterias and promenade spaces, offering the possibility of spending a lengthy time. Unirii and Victoriei Squares both host city festivals and concerts, mass gatherings for electoral rallies, or other mass events. pecial attention should be given to parks; Timisoara brands itself as "the rose city" or "the city of parks". From April through to October, the weather in Timisoara allows strolls in the open. The Rose Park, located near the student campus and the city center, has a summer theater where various concerts are held and where large graduation ceremonies for students have been organized since 2017. All the nominated parks are used as venues for photo sessions on special occasions (birthdays, baptisms, weddings), so they are quite visible on social media.

5. Discussion

While the three analyzed cities have different histories and cultural landmarks, it is interesting to note the coincidence of so many characteristics identified during the survey of young people. Their choices of historical and architectural landmarks largely coincided with those mentioned in tourist information for visitors to the city [33,35,37] and/or present on various memorabilia. Despite the presence in the city of buildings belonging to the socialist modernist period, young people singled out mostly buildings and places of earlier times, prior to socialist urban projects, except for in Yekaterinburg. In this city, students identified as worthy of attention two buildings both inaugurated in 1954, the city Duma and the college named after I. Polzunov. Most probably this was due to the central location and the functionality of the places (the college being the main educational space for the respondents). Three out of eight places worthy of showing to visitors belong to post-socialist times: the Yeltsin Center, the Vysotsky skyscraper, and the church erected in the memory of the last Russian Tsar, The Temple on the Blood. These places have undergone a process of "heritagization", as Gravari-Barnas has defined it [38], indicating that the demand for heritage (history, meaning, and transmission) becomes "increasingly pressing in the context of hypermodern societies" [38]. Gyumri and Timisoara, unlike Yekaterinburg, have shown a careful approach to historical sites, and socialist or post-modern buildings are not strikingly present in the hearts of their city centers. In Gyumri the only cultural object mentioned by respondents related to the socialist period was the Mother Armenia complex (1975), due to the high visibility of the monumental statue on top of a hill, and the forest and promenade space nearby. Respondents in Timisoara did not nominate any of the socialist-period buildings, although such references can be found in recommendations to tourists [37]. For their leisure time, students declared that they gravitate towards places with historical architecture or green spaces, allowing communion with nature, without travelling far. Students' awareness of the landmarks of the city represents potential that can be tapped by inviting young people to co-create meanings and branding for their native city or the city chosen for their studies.

The survey method and the visualization of its results allowed us to critically assess how historical and cultural (historical–architectural) objects are included in the consciousness of young people, forming an attractive image and positive perception of their city. While the histories of the three cities are different, it is interesting fact that young people were found to value objects of cultural and historical heritage and architecture mainly from the pre-socialist past, but not older than two centuries. Secondly, in almost all cases the attention of young people was not focused on the architecture of the twentieth century's socialist period, despite its presence in the centers of the analyzed cities. Thirdly, the ratio of the visibility for objects of cultural and historical heritage and architecture favors the city center in all the three cases. This can be explained by the fact that resources invested in landscaping are usually applied in the centers of cities, so the urban infrastructure is better where public spaces such as squares were initially and historically formed. In addition, the convenience of location and its functionality for walks are superimposed onto the traditions of pastime, which have been formed by similar procedures for organizing mass events in different cities, including family traditions of organizing leisure activities. Fourthly, young people react in their representations to the information background, where objects attractive to guests in the city are reflected and especially promoted through various channels, aligning perceptions of the cultural and historical context of urban development. All the presented objects have a vivid presence in of their respective city's representation for tourists, being promoted in city maps, tourist information packages, proposals for tours, posters, postcards, and other memorabilia [33,35,37].

Heritage is a dynamic creative process that occurs in many dimensions, by which society unites, protects, enriches, and projects its culture [1,4,8,38,39]. The results of the current study confirm this standpoint, and encourage the adoption of development strategies that consider the emotional attachment of people towards urban places. In Montgomery's terms, all stakeholders should pay attention to how buildings, public spaces, and mobility systems influence the social lives of inhabitants [40]. Such an effort can foster development strategies in which the social city, the sustainable city, and the happy city are the pursued project. Happy, lively, and livable cities do not belong only to utopian or romanticized visions of urban life, but can be attained if enough energy and skilled innovation are put into the effort.

The potential resource of youth participation in the development of urban areas is huge, but work with this theme can only be based on engagement and sustained interest [4,8,9]. The involvement of young people in the development of urban spaces (as volunteers or brand ambassadors) should be aimed at the reorganization and improvement of places that are well known and significant for those young people, in a form where their interests and proposals can be considered. The participation of young people in the production of places will allow the development of places corresponding to the ideas and expectations of the modern generation, and promote an increased attachment to it, increasing its significance, and contributing to a responsible attitude to the urban environment [17,21,39].

6. Conclusions

The direct link between a harmonious city environment and the positive attitude of the population towards their home city is becoming increasingly clear. This attitude serves as a source of sustainability for the city. It is determined not only by specific places and objects and their placement in the urban environment, but also by the kind of social interaction that these spaces create [9,17,20,21,41]. In each of the analyzed cities, the leading positions in the imaginations of generation Z students are central squares, which are open spaces surrounded by historical buildings. The urban interiors of these places have been developing for a long time and have become a hallmark of each city, one of the key elements of its individuality. These spaces are formed by buildings of different epochs, styles and materials, small architectural forms, as well as seasonal retail outlets, with elements of the landscape changing from year to year. They are of interest for young people as locations for meetings, social gatherings, and various leisure activities. Such a preference for a certain location increases the importance of the place in the eyes of young people (creating memories, increasing the degree of involvement in city life) and in the eyes of the city administration (as an obvious indicator of the popularity of the place). These places of action convert the cities we live in into living works of art, where all citizens can interact and fully engage in the process of urban design and development [4,21,40].

Regional cities need to work more actively with their symbolic capitals. At the same time, there should be no arbitrary decisions, because the responsibility is great. Today it is recognized that "replanning and redesigning the processes of life in our cities... is what worries both institutions and citizens. To be successful and meaningful, such processes must be supported by research . . . " [26]. Generation Z students live, pursue education, and plan to seek employment in "shifting times" [11,12]. Unless their voices are listened to, making room for their preferences, readiness to action, and energy [1,13,41], they may disengage and seek other places to satisfy their needs and aspirations [4,13]. The 2020–2021 pandemic created a disruption in "the way things are" and the announced "new normal" requires new ideas, fresh thinking, and processes and procedures that citizens will acknowledge as legitimate and "their own" [41,42]. Therefore, it is to be expected that post-pandemic urban planning will pursue humanistic goals, and at the same time consider the preferences and value priorities of young people, while engaging them and inviting them to take part in meaningful projects, including re-socializing cities and re-opening them to visitors and newcomers, as part of a steered (vs. chaotic) "place production" process [17,21,39,41].

7. Limitations of the Study

This study has several potential weaknesses. First, the study was conducted during the isolation period triggered by the COVID-19 pandemic, relying on students' memories and recollections of historical heritage and places of gathering. Another survey might bring forth additional nominations and images. Second, these results can be complemented with investigation of students' actual behaviors and engagement in local projects for promoting and upholding the city brand through volunteering or other means of engagement. Last, but not least, further study will investigate the incorporation of city attractiveness in the educational marketing of universities, to grasp the engagement of universities themselves with the societal environments where they operate. Such extensions of the study can be beneficial to both universities and to city officials, fostering synergy between efforts to increase regional cities' attractiveness and their capacity to retain youth, and ensuring the sustainable development of the respective regions.

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heritage

Article

The Narrow Mausolea at Conchada Cemetery as Part of Portuguese and European Architectural Heritage

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Abstract: Over millennia, death was the origin of great funerary constructions that have come down to us. These constructions aimed at ensuring eternity and perpetuating memory. Funeral art thus appears not in the service of death, but in the service of memory. In the modern age, funerary constructions do not have the dimensions and grandeur they did in ancient times, but there are still constructions with relevant architectural interest, built to perpetuate the memory of important families. In Conchada Cemetery, located in Coimbra, Portugal, a vast and diverse funeral heritage exists. Possessing various architectural styles, almost all built with limestone from the region, the narrow mausoleums stand out from this heritage. This work presents a study carried out on the architecture and construction of two types of narrow mausoleums, existing in the Conchada Cemetery, both of the Neo-Gothic style: one with an entrance from the front, and another from the back. As it is not possible to present the photographs of the burial vaults, since it would represent an intrusive approach to the families, the authors have resorted to representing them through Indian ink and watercolor illustrations.

Keywords: funeral heritage; mausoleum; architecture; construction; architectural styles

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1. Introduction

Secular cemetery spaces are usually spaces of great historical, architectural, artistic, symbolic, and social value. They are also a testimony to the heritage of collective memory and to trends and traditions associated with the cult of death throughout the ages. The perception of death depends on the historical moment, as well as the social and cultural context in which it is inserted. During the Middle Ages, there was a proximity between the dead and the living, in which the living usually shared the space with the dead. During this period, burials were carried out in churches, a period that preceded burial in public cemeteries and which followed burial in necropolises outside the cities.

The word "cemetery" comes from the Greek verb *Krimao*, meaning "I rest, I sleep", and, thus, the word *Krimeterium* means "dormitory". The corresponding Latin word, *Coemeterium*, expresses the idea of "place to sleep and rest". For Christians, the "last place of rest" (the cemetery) is also a present relationship of continuity between the community of the living and that of their dead, indispensable to the cultural identity of people, from the individual to the family and to the nations. The cemetery, an element of landscape and basic heritage of culture and history, is one of the most significant links that connect rural and urban culture within the same community.

Burial places emerged as a way of maintaining the memory of the dead [1]. This objective, allied with the needs for preventive actions against contagious diseases, improvement of hygiene conditions, and population increase in urban centers, demanded the development of structures that could simultaneously attend to all this objectives at once. Thus, public cemeteries located in the cities' outskirts started to be designed.

Pére Lachaise cemetery, in Paris, was the first to be built outside the city [2]. It was inaugurated in 1804 by Napoleon Bonaparte and designed by Alexandre Théodore Brongniart. Pére Lachaise is the largest cemetery in the city and one of the most visited cemeteries in the world. It is a true open-air museum that houses many architectural and sculptural works of funerary art. Burial structures are built in several art styles, including Gothic, Romanesque, Neoclassical, Italian Renaissance, and Art Nouveau crypts, alongside Egyptian Renaissance pyramids and obelisks.

It is important to stress that, in the Catholic world, there was a strong concern with ensuring resurrection. Thus, every person desired to be buried inside a church, and close to the altar. As burial inside churches along Europe started to be prohibited due to health requirements, the solution of burial in a chapel-shaped tomb that appears for the first time in the Pére Lachaise cemetery comforted people's religious concerns. Soon, this practice was followed in cemeteries along Europe.

In Portugal, cemeteries as public burial spaces have a short time span in historical memory. Until the beginning of the 19th century, burials were carried out in religious spaces. This practice was not bearable with the increase in population, as well as with times of great mortality caused by epidemics. Already in the 18th century there were attempts to impose cemetery legislation. However, only in the 19th century did the laws effectively gain force. The implementation of such legislation did not take place peacefully. The population offered great resistance to these changes, giving rise to revolts, namely the well-known Maria da Fonte revolt [1], which will go down in national history as the revolt of the "Minho women". This revolt, as well as its influence on posterior burial rites, is eloquently described by the Portuguese writer Camilo Castelo Branco, contemporary to the events, in his novel "Maria da Fonte" [3]. The Portuguese population, deeply marked by traditions of a strongly religious nature, did not want to bury their people outside the churches and, consequently, away from the sacred [4]. Despite all the riots and protests, public cemeteries in Portugal became a reality in 1835. While in the rest of Europe these spaces were secular, in Portugal, it was still mandatory for the cemetery ground to be blessed and possess an appropriate space for worship [5]. In this way, an attempt was carried out to attend to some of the demands of a fundamentally catholic people.

Through the way in which the dead are remembered and the buildings that are constructed, the cemetery is a space that shows the existing stratifications of social order. In this sense, death accentuates social differences. The tomb layout existing in a sacred field reflects social hierarchies, as well as other forms of segmentation. Funerary art also became another differentiating element of social classes. The tomb became a physical and manifest place for memories and property, which guaranteed the perpetuity of the deceased.

The graves, individualized through their architecture, sculptures, and symbols, demonstrate the desire to perpetuate the identity of the dead, seeking to preserve the memory of the deceased from the richest classes, and also to confirm and sacralize their historical and social positions.

In Portugal, a vast existing cemetery heritage contains important and diversified tomb art. This paper is part of a vast study of the chapel-like mausoleums of the Conchada Cemetery, located in Coimbra. Some of the narrow mausoleums have their entrance in the front, while others have it in the back. The back façade is practically an exclusive form of construction of this cemetery. Some studies have been carried out on Conchada Cemetery, comparing it with other European cemeteries [6]. However, although the Conchada Cemetery has a rich set of narrow mausoleums, there is no detailed study on them. This paper aims at describing and characterizing the existing mausoleums in Conchada Cemetery, describing the architectural types they can assume.

In carrying out this work, some constraints were experienced. The first one has to do with the impossibility of accessing the archive of the graves' design projects, as its location, or even its possible existence, is unknown. This would be important in order to establish a chronology of the mausoleums' construction. This fact limited the study of the tombs to the oldest nucleus of the cemetery, built between 1856 and 1918. The second constraint resided in the impossibility of obtaining photographic records. This situation was circumvented through representations drawn in Indian ink and watercolors, a more consensual solution, taking care not to identify the vaults by the families' names. The recognition of the constructive system in a non-intrusive way is not difficult, as the mausoleums studied possess a single compartment, and they were built without a differentiated structure. The coating of thin stones is interconnected by metallic pieces, constituting the walls and roofs, thus making the construction process easily understandable.

2. The Conchada Cemetery

On September 21, 1835, on the initiative of Rodrigo da Fonseca Magalhães, a national legislative document (Decree-Law No. 442205) in defense of public health and the need to observe sanitary standards was published [7]. This law prohibited burials inside religious buildings and their surroundings, thus leading to the need to create public cemeteries in all villages of the country.

The Conchada Cemetery, in Coimbra, is part of this panorama. In 1835, the mayor, Visconde das Canas, had already asked for land on which to build a cemetery. For some years, the construction of the cemetery was stopped, justified by the supposed lack of a place for its implantation. For a long time, a plot of land located in the "Cerca do Colégio de Tomar" was assigned for the cemetery. Nowadays, this is the place where the city prison is located. It was only in 1851 that the cemetery was definitively established in the place where it stands today, Conchada. The Conchada was chosen, to the detriment of the "Cerca do Colégio de Tomar", since it met the necessary conditions for the implantation of a cemetery. The Conchada was located at a reasonable distance from the urban core. Its location was northward from the city, which made it possible to protect the city from east, south, and west winds, impregnated with cadaverous emanations. At the geological level, it had ideal conditions for the putrefaction of corpses, and its extension allowed for the location of a large number of graves [8].

The oldest nucleus of the Conchada Cemetery was built between 1856 and 1918. It contains a rich and expressive set of mausoleums. These structures are chapel-type constructions, almost all built with limestone from the region, the Ançã stone (Figure 1). Ançã stone punctuates the space because of its ease of cutting and working and for its abundance in the region.

Figure 1. Partial view of a sector at the Conchada Cemetery.

Construction work on the Conchada Cemetery began in 1854, following the design of physician Raymundo Venâncio Rodrigues [9]. This design consisted of a vast hexagon with

11,750 m^2, divided into four sectors. These sectors were, in turn, divided into four lots each. The 200 mausoleums were planned, arranged on the perimeter of the pillars, inside which the space was reserved for 4511 graves (Figure 2) [6].

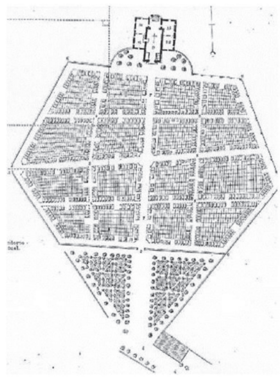


Figure 2. Conchada Cemetery, according to Raymundo Venâncio Rodrigues design, 1857 [6].

In 1855, Portugal was hit by a cholera epidemic. The Conchada Cemetery construction was not complete, and it was necessary to create a temporary cemetery. This fact explains the existence in Conchada of graves with death dates prior to the entry into operation of the cemetery. Wealthier families also had their deceased moved to Conchada, due to the social prestige of having a mausoleum.

The cemetery was opened and subjected to Catholic blessing rites on 1 October 1860. Official burials began on October 22 of the same year. This work was embargoed for 25 years, and, even after being open to the public, improvements were deemed necessary. The construction of the existing chapel was only completed between 1868 and 1869.

The peak of the construction of the tombs in this cemetery occurred in the 1870s and 1880s, that is, in the final period of Romanticism [9,10]. This cemetery is, therefore, one of the most important and interesting cemeteries in the country in terms of funerary art. The cemetery presents very specific aesthetics in the art of stonework and metalwork, constituting an authentic open-air museum space.

Later, in 1918, to meet the needs of the growing city population, the cemetery was expanded to the adjacent lands belonging to the Coimbra Santa Casa da Misericórdia [11].

Coimbra funerary art was already well-known during the Middle Ages. With the construction of the Conchada Cemetery, this activity regained its importance, and the number of commissions and artists increased greatly. These small-scale constructions represent a type of city of the dead, also divided by streets and avenues. The typology of the "small chapel" was the most used, followed by small-scale revivalisms, especially Neo-Romanesque, Neo-Gothic, and Neo-Manueline. The characteristics of these architectonic styles are briefly presented in Section 4 of the preset paper. These artistic revivals were the most used because 19th century Portuguese society dedicated a great effort and investment to restore medieval and Manueline works. The restoration work revived a passion for the past, which is reflected in the final resting place chosen by many. When observing these small monuments, it is still possible to identify the traditions left by great names of Coimbra, such as Hodarte and João de Ruão [10].

In addition to the "chapel" typology or revivalisms, in Conchada Cemetery, there are other artistic manifestations. One may observe examples such as bas-reliefs. The lamenting woman is a common theme, in addition to small architectures that seem, effectively, to be inhabited houses. In this last typology, ironwork stands out, and it is possible to observe that some mausoleums "conquer" land around them with a railing that resembles a porch, which delimits the space of each family or individual.

The cemetery space of Conchada, still functional nowadays, resembles an open-air museum, where artistic manifestations proliferate and, even after life, continue to distinguish individuals. The final destination may be the same, but the place of eternal rest can be quite different—a place that urgently needs to receive the protection and the respect it deserves.

3. The Mausoleums

In the Conchada Cemetery, mausoleums are buildings that seek to reproduce, in smaller dimension, chapels. In constructive terms, they do not have a support structure; they are built with just stone plates, interconnected by metal clamps, possessing only one compartment, inside which the coffins, sealed with sheets of lead or tin, are deposited. Access to the interior of the mausoleums is usually made through small wickets or via an iron gate.

The mausoleums were built in a period when a new wealthy industrial bourgeoisie sought to assert itself in relation to the aristocracy at the end of the Romantic period [12]. This age was characterized by sentimentality and fantasy; the burial structures were conceived with an exuberant architecture enriched by exquisite iconography, as illustrated in Figure 3 [13].

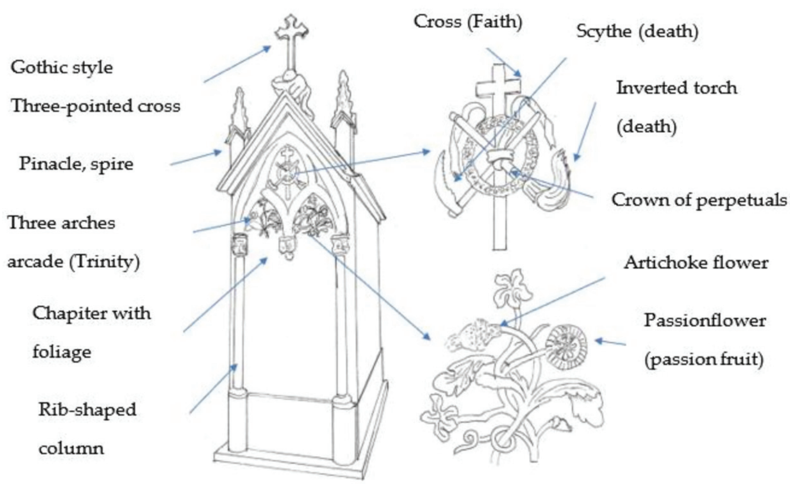


Figure 3. Example of mausoleum iconography.

The cemetery is eminently a symbolic space. The stonework decorations on the tombs and mausoleums create symbols, essential elements in the process of communicating feelings and desires.

The flowers, leaves, and fruits that represent the victory of the human soul over sin and death are symbols of life and of eternal life. They are often associated with nobility and beauty, but also with fragility. The perpetual flower, together with the artichoke, is the most represented flower in many cemeteries, representing perpetual longing. The perpetual is originally an herbaceous plant with purple flowers, and its representation in burial structures is directly related to its name. The artichoke is also known as "Saudade" ("longing"): it is a cyclically regenerated plant. Its design represents absence and permanent nostalgia. The acanthus leaf is the symbol of immortality.

Among other symbols, the crown stands out. The symbol pays homage to the deceased and, due to its shape, without beginning or end, symbolizes eternity. The vessel, which is usually represented as being empty, symbolizes the body separated from the soul. The globe symbolizes the use and end of the terrestrial life span. The palms of branches prefigure the resurrection of Christ, after the Calvary drama. The angel, when the hand points to heaven, means that the deceased was taken as a good person and is expected to go straight to paradise. The casket symbolizes separation, mortality, and the spoils of life. The scythe is the instrument that death, personified in the reaper, uses to harvest souls.

The Cross is also a frequent symbol. The Cross is the symbol of Christianity. With different shapes and sizes of arms, wanting to represent a diversity of meanings, this symbol is used by a multitude of Christian-based cultures. The Christian Cross, also called the Latin cross, has a vertical arm that is longer than the crossed one. The Romans used this type of cross to execute criminals, and Jesus Christ was, thus, sacrificed upon one. This symbol represents resurrection and eternal life. The Trinity Cross, or clover, represents the suffering of Jesus Christ in his crucifixion, in which the ends of three intersecting circles represent the Trinity. The Passion Cross, which is the Latin cross with pointed ends, represents the suffering of Jesus Christ in his crucifixion.

Another aspect of funerary symbology refers to professional symbols that are associated with a varied set of professions or the branch of business practiced by the mausoleum family owner.

Usually in Portugal, chapel-type tombs have a small space for gathering inside, where family members can have some proximity to their deceased (Figure 4a). In the Conchada Cemetery, in addition to traditional mausoleums, there are narrow tombs with no possibility of staying inside, and their small interior space is completely filled with shelves for the accommodation of coffins or urns (Figure 4a,b). These are introduced through the metal gate at the front, or through small hatches at the back.

(a) (b)

Figure 4. Mausoleums: (**a**) with space for visitors to access inside; (**b**) narrow tomb with no possibility of access for visitors to its interior.

4. Narrow Mausoleums and Their Architectural Styles

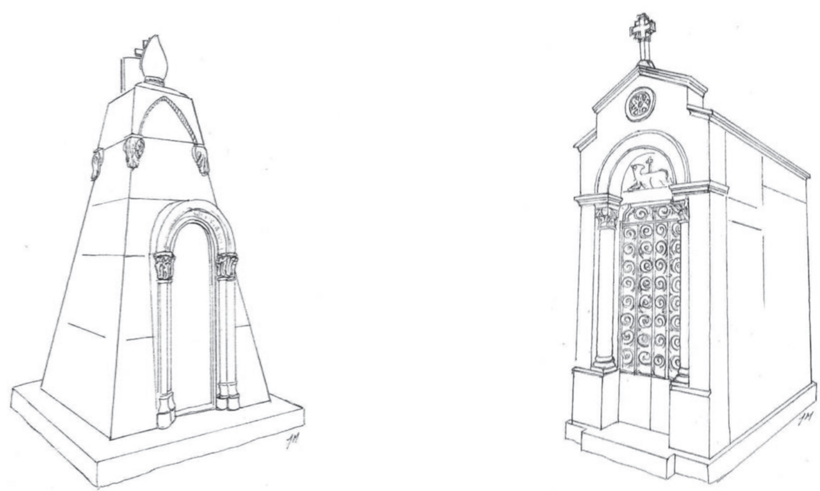
The narrow mausoleums constitute “small chapel-shaped mausoleums”. They have a width of only 1.2 to 1.5 m and a length of about 2.5 m. Funerary structures this wide are not very common in Portuguese cemeteries, especially those with an entrance from the back, so it is believed that it could be a regional form of burial [14].

These mausoleums form remarkable sets, characterized by having a very diverse and rich stylistic and iconographic expressiveness (Figure 5).

All architectural expressions and forms reflect different moments of society, translating the way of life of different groups that make up that society. These architectural expressions are materialized in buildings and spaces built by the ruling classes, who use them as landmarks of passage and dominion over others. As an integral part of this scenario, cemeteries are no exception to the rule, becoming places for demonstrations of wealth and social power, and showing a clear hierarchy of spaces. Thus, the funerary buildings of the wealthiest people and those with greater social power adopted the architectural styles that were the fashion at the time of construction, in terms of execution and artistic decoration of their tombs. Architectural styles are therefore excellent sociocultural markers and important chronological markers.

In Conchada Cemetery, the narrow mausoleum assumes, in a very creative way, different styles, such as the Neo-Egyptian, the Neo-Romanian, the Neo-Gothic, the Neo-Manueline, the Neo-Classical, the Neo-Baroque, the Beaux-Arts, Art Nouveau, Art Deco, and even Casa Portuguesa (Portuguese House), which coexist randomly throughout the cemetery (Figures 6–10). An interesting curiosity is that the narrow mausoleum, being a local typology, does not follow the French models widely disseminated through architectural manuals [12].

Figure 5. View of a set of narrow mausoleums.



(**a**) (**b**)

Figure 6. Examples of architectural styles of the narrow mausoleums: (**a**) Neo-Egyptian and (**b**) Neo-Romanesque.

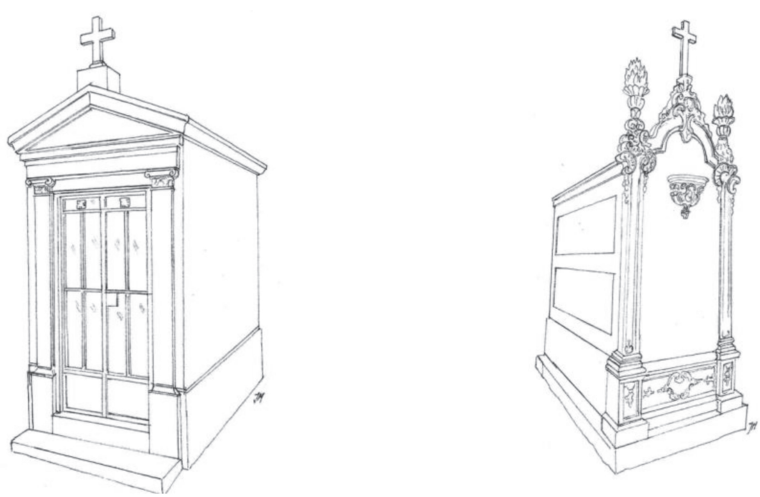
The different styles displayed by the narrow mausoleums are well identified and are recognized by the artistic and architectural symbols, techniques, and materials characteristic of the time in which they were built.

The Neo-Egyptian-style narrow mausoleums present the foundations of Egyptian architecture, containing porticos with sloping walls, reminiscent of the pyramids, with elements alluding to Egyptian art, such as the winged sun (Figure 6a).

In Neo-Romanesque structures, one may see a set of characteristic symbols. The most used ones are certain flowers and plant wreaths, allegorical figures (namely those representing Christian virtues), certain animals (such as the dog, to demonstrate fidelity), the cross (as a symbol of the Christian faith), inverted torches, hourglasses and genies of death (inspired by the tombs of Classical Antiquity), and angels (of different types), among many others (Figure 6b).

(**a**) (**b**)

Figure 7. Examples of architectural styles of the narrow mausoleums: (**a**) Neo-Gothic and (**b**) Neo-Manueline.



(**a**) (**b**)

Figure 8. Examples of architectural styles of the narrow mausoleums: (**a**) Neoclassical and (**b**) Neo-Baroque.

The Neo-Gothic style, in the 19th century, contains elements that allude to the architecture of the late Middle Ages. There is a reinterpretation of the Gothic style: verticality, pointed arches, spires, pointed and slender towers, slope of the roof, battlements, stained glass windows, and glasses. The characteristic constructive system consists of stone masonry, as well as the use of iron in the structure (Figure 7a).

Neo-Manueline was a revival architecture and decorative arts style developed in Portugal between the mid-19th and early 20th centuries. The style adopted the characteristics of Manueline (or Portuguese late Gothic) of the 16th century. The Neo-Manueline is a revivalist architecture, typically romantic, which copies the most superficial aspects of the Manueline decoration, applied in buildings adapted to the needs of its time. It is based on the technical advances that came with the industrial revolution, both in terms of materials and machines, hiding modern constructions, often with metallic structures (the vanguard of the time). It uses all kinds of innovations, such as bricks or industrial ceramics, preserving, whenever possible, basic issues developed in Neoclassicism, such as the functionality and profitability of architecture, simply adapted to other aesthetics [15].

(**a**) (**b**)

Figure 9. Examples of architectural styles of the narrow mausoleums: (**a**) Beaux-Arts and (**b**) Art Nouveau.

In the Neoclassical style (Figure 8a), the following elements of Greco-Roman architecture, Renaissance, and Mannerism appear: full arches, triangular pediments, entablatures, architectural orders (Doric, Ionic, Corinthian, Tuscany, and Composite), podiums, and domes. The construction system is based in stone masonry, with marble or granite finishing. Whitewash and even tiles could be used.

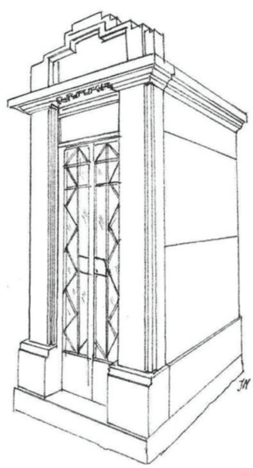
The narrow mausoleums from the Neo-Baroque period (Figure 8b) have volutes on the pediment and pillars (not columns), alluding to the Ionic architectural order.

Beaux-Arts (Figure 9a) relied on sculptural decoration along modern, conservative lines, employing French and Italian Baroque and Rococo formulas combined with an Impressionist finish and realism. Slightly over-scaled details, bold sculptural support consoles, cornices rich in depth, garlands, and sculptural enrichments in the brightest finish the client could give. Features of Beaux-Arts architecture include the following: flat roof, arched windows, and arched and gabled doors. The classical details include the following: references to a synthesis of historicist styles and a tendency toward eclecticism; symmetry, sculptures (bas-relief panels, figurative sculptures, and sculptural groups), murals, mosaics, and other works of art, all coordinated in the theme to affirm the building's identity. Classical architectural details include the following: balustrades, pilasters, garlands, cartouches, and acroteria, with a prominent display of richly detailed brackets (staples), brackets, and support consoles; moreover, subtle polychromy in also included.

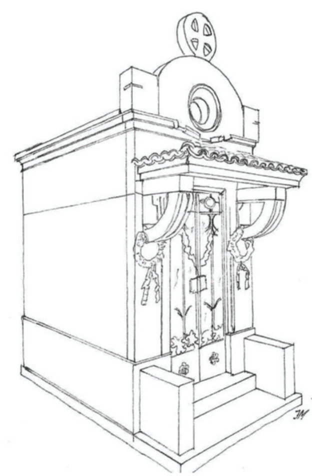
In the Art Nouveau period in Portugal, funeral art contains floral motifs (palm leaves, roses, etc.) and curvilinear lines, glasses, and stained glass. The materials used consist of iron, concrete, bronze, and glass [16]. These motifs are implemented in the railing, in the door frames of the mausoleums, and also carved into the statues and pedestals and even in the mausoleum structure (Figure 9b).

From the beginning of the 20th century to the period between the two world wars, Art Deco [17] appears (Figure 10a). The characteristics of this style are symmetry, geometric figures, the predominance of straight lines, scaling, superimposed planes, curves, friezes giving the idea of movement, and stylized nature (flowers, animals). The construction system makes use of reinforced concrete. The finishings include the following: marble, granite, and stone powder. In the first half of the 20th century, the modernist period emerged, characterized by the absence of ornaments, wide openings, and the use of reinforced concrete.

The aesthetics of the Portuguese House style (Figure 10b), according to Raul Lino's formulation, merge the imagery of the family house (balconies, arcades, porches, flower beds and flower boxes, sloping roofs, eaves, spires, weathervanes, and panels of tiles) with that of a village church, including bell towers and a finishing cross [18].



(a)



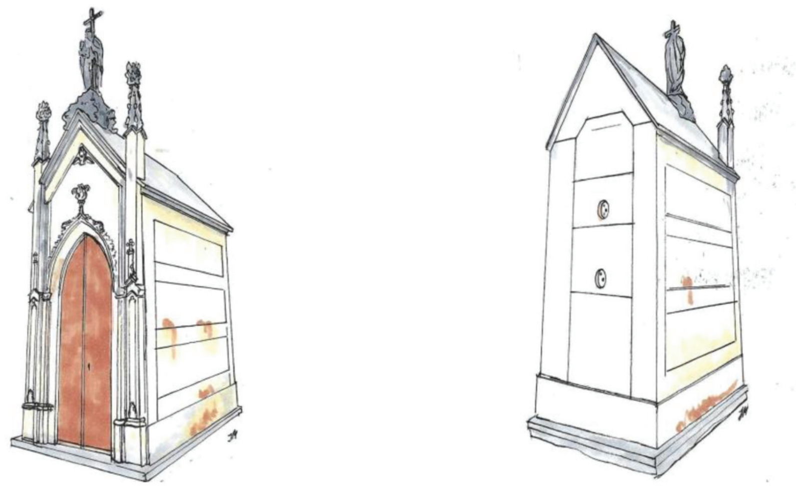
(b)

Figure 10. Examples of architectural styles of the narrow mausoleums: (**a**) Art Deco and (**b**) Portuguese House.

5. Access to the Interior of the Mausoleums

As previously mentioned, there are two ways of accessing the interior of the narrow mausoleums: from the front of the structure and from the back.

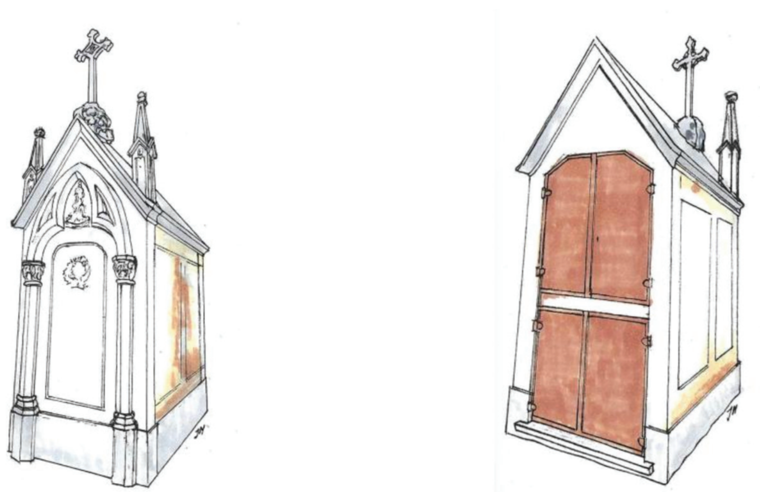
Narrow mausoleums that have the entrance located in the front are usually higher and may have a conditioned access from the back, materialized through removable stone slabs, thus making it possible to take advantage of the upper part of the deposit (Figure 11a,b).



(**a**) (**b**)

Figure 11. Perspectives of a Neo-Gothic tomb with access from the front: (**a**) view from the front and (**b**) view from the back.

The mausoleums with access via the back are lower, and the main façade, in the area where the access gate would be, is filled with iconographic symbols (Figure 12a,b). The entrance through the back made this type of mausoleum less expensive, as it did not possess a decorative metalwork gate.



(**a**) (**b**)

Figure 12. Perspectives of a Neo-Gothic mausoleum with access from the back: (**a**) view from the front and (**b**) view from the back.

6. Conclusions

The narrow mausoleum typology, despite having a generic construction form similar to that of traditional mausoleums, has a very unique visual character that is characteristic of the Conchada Cemetery. This type of mausoleum assumes a wide variety of architectural styles and is presented in two types: one in which the entrance is made at the front and the other with the entrance at the back. The narrow mausoleums with an entrance from the back would be more economical, as they do not have a door made of decorative metalwork; however, they still have a rich and varied iconography.

The narrow mausoleums form remarkable groups which distinguish the Conchada Cemetery from others spread across the country. Considering this fact, it would be important to deepen its study and promote its protection and classification as a differentiated funeral heritage in the European panorama.

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sustainability

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Evaluation of Urban Sustainability in Cities of The French Way of Saint James (Camino de Santiago Francés) in Castilla y León according to The Spanish Urban Agenda

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Abstract: The emblematic French Way of Saint James (Camino de Santiago Francés) crosses towns, cities, and Spanish regions to the Cathedral of Santiago de Compostela (Galicia, Spain), However, *where is The French Way of Saint James going with respect to the urban sustainability of its host cities?* As each city is unique and urban sustainability favors the revitalization and transition of urban areas, to know where to go, it is first necessary to establish a diagnosis that makes the different urban situations visible. In this article, the behavior of urban sustainability is analyzed in the six host cities of The French Way of Saint James in the Autonomous Community of Castilla y León, a region characterized by its link with the rural environment and its current depopulation problems. The data and indicators used are officially provided by the Spanish Urban Agenda, which, through the normalization of its values, are able to territorialize the SDGs at the local level and reflect the realities of the cities of Burgos, Astorga, Cacabelos, León, Ponferrada, and Valverde de la Virgen. The results make it possible to diagnose and compare these host cities, identifying weaknesses, skills, and opportunities that favor the promotion of action plans, local or joint (favored by The French Way of Saint James), in the multiple aspects of sustainability. In addition, they show that Valverde de la Virgen is the city with the best performance in terms of urban sustainability.

Keywords: sustainability; urban sustainability; SDG; Spanish Urban Agenda; The Way of Saint James; Camino de Santiago

1. Introduction

The challenges of urbanization and demographic change are increasingly recognized as components of resilient and sustainable development [1], especially in a context where the world's population is expected to reach 10 billion people by the year 2050, with 68% located in urban areas [2]. The society and the world of the 21st century, which are eminently urban, are "incorporating one of the deepest and most accelerated transformations in the history of humanity" [3]. There is no doubt that we are facing a major epochal change [4].

It is urgent to change the current models of urban development from the perspective of sustainable development, climate change, and resilience to natural and technological disasters, and improve the quality of life, social integration, and equity [5–7]. However, to know what we need to change, we need to know where we are and where we are going.

Today, around 75% of the European population lives in urban areas. Estimates predict that the European urban population will increase to 80% by 2050 [8]. For this, it is vital to ensure a sustainable urban environment, knowing that cities are the engines of Europe's economy and are increasingly recognized as key players in the transition to a low-carbon economy [8]. The EU has a key role in promoting sustainable urban development [8] and considers that urban environmental sustainability encourages the revitalization and transition of urban areas and cities to improve the quality of life, promote innovation, and reduce environmental impacts while it maximizes economic and social co-benefits. The European Environment Agency considers urban sustainability from an environmental perspective achieved by focusing on environmental issues in urban areas such as air and water pollution, green spaces providing space for people and nature, biodiversity loss, resource efficiency, and mitigation measures to reduce greenhouse gas emissions and manage the impacts of climate change (Figure 1).

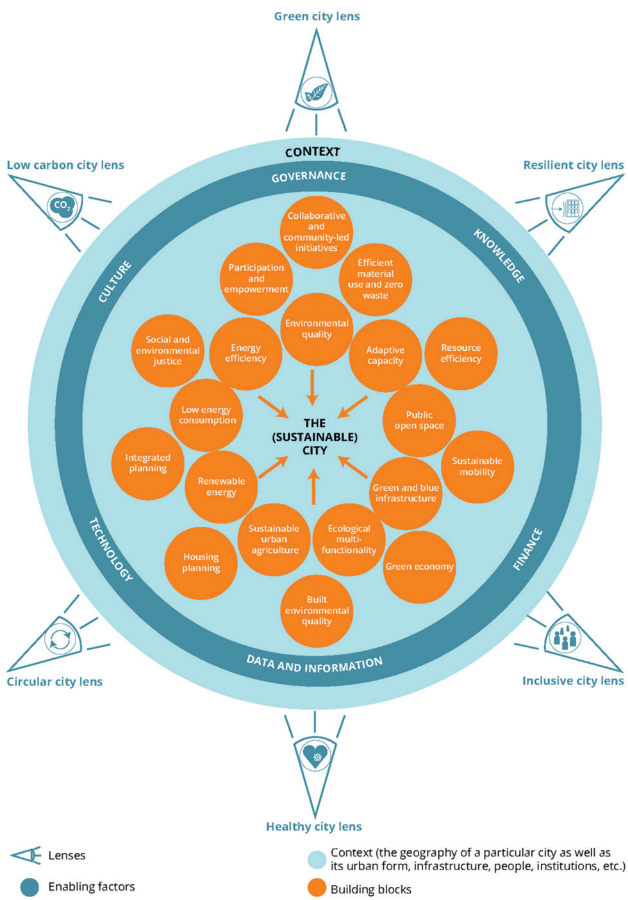

Figure 1. Conceptual framework for urban environmental sustainability. Source: European Environment Agency, 2021 [8].

In Spain, according to the Spanish Urban Agenda of 2019 [9], an important document in this article, the population percentages mentioned recently have already been reached. Spain is among the countries with the highest percentage of urban population in the

European Union (EU): of the 46,528,024 people that exist in the Spanish territory, 80% are concentrated in urban areas, which account for only 20% of the territory [9]. Spanish cities constitute, in many aspects, a reference in the European context due to their traditional compact city model, and a long tradition of urban planning and policy that has allowed rigorous action to be taken in the regeneration of centers and interior reform [10].

In this context, the search for sustainable development at the urban level and how cities, with their diverse conditions, characteristics, and available resources (sometimes limited), can move towards their own sustainability are of interest.

At the international level, the Sustainable Development Goals (SDGs) have emerged as a universal call to improve lives around the world. In 2015, all member states of the United Nations (UN) approved 17 SDGs, consisting of 169 targets and many indicators [11], as part of the 2030 Agenda for Sustainable Development. Since its launch, progress has been made on many SDGs. Nevertheless, the overall action to achieve all the goals is still not moving at the right speed and scale [12]. Even before the COVID-19 pandemic, which has unleashed an unprecedented social, environmental, and economic crisis, progress towards the SDGs was uneven and not on track to meet them by 2030.

Spain, similar to most European governments, is committed to the SDGs and the 2030 Agenda. In fact, the National Government of Spain has made an official document called the "Spanish Urban Agenda" (2019) that serves as a reference framework for urban areas with a focus on sustainable development and the 2030 Agenda. The Spanish Urban Agenda (SUA) stands out as a roadmap that can show the way to make Spanish towns and cities friendly, welcoming, healthy, and conscientious areas of coexistence by 2030. Although the SUA is focused on SDG 11 "*Make cities and human settlements inclusive, safe, resilient and sustainable*", it is also fully aligned, directly and indirectly, with the other SDGs.

The SUA is linked to the European Urban Agenda, which appears as an important reference due to its innovative methodology based on the principles of multilevel governance [10]. As a key objective, the adaptation of the economic programs of the European Union to the real challenges of the cities is useful in defining future actions that propose that the Spanish Urban Agenda adopts the necessary changes needed by the planning and management of urban policies [10]. The promotion by the European and Spanish institutions of a sustainable city model constitutes an opportunity to implement local Urban Agendas as documents that are required to structure an integrated vision of local urban policies from which different urban plans, mobility, energy, housing, environments, and economy can be developed [10].

Furthermore, the SUA is a very useful official tool for analyzing Spanish cities in terms of sustainability, as it has a system of indicators and a series of guidelines that allow diagnosis, monitoring, and revision of its own contents. On the one hand, the SUA presents purely descriptive data that is supplied by the General State Administration and, on the other hand, the SUA presents evaluation and monitoring data. This is important because urban areas are considered to be a reflection of the victories or defeats in the battle for sustainability [9] and its success will depend largely on the ability to reorient current urbanization processes from public management and policies [7]. This sentence outlines a challenge that can be faced with the economic tools and knowledge but whose success will ultimately depend on the collective political [7]. Considering the SUA as an excellent opportunity to incorporate sustainable development in Spanish cities, this article uses its data to analyze the host cities of The French Way of Saint James (Camino de Santiago Francés in the Spanish language) in the Autonomous Community of Castilla y León (according to the area affected by the declaration of the historic set of The French Way of Saint James in Castilla y León) [13]. From this perspective, the enhancement of cultural heritage can play a decisive role, not only in terms of increasing the life cycle of the heritage but also as an urban strategy capable of generating new economic, cultural, and social values, supporting the innovative dynamics of local development [14].

The SUA presents a territorial diagnosis and synthesis and descriptive indicators for cities with 5000 people or more (considering the urban population of 2019). Therefore, the cities contemplated in this analysis are Astorga, Cacabelos, León, Ponferrada, and Valverde de la Virgen (from the Province of León) and the city of Burgos (from the Province of Burgos). It should be clarified that Cababelos, in 2019, had a population of more than 5000 people; however, in the last 2 years, its population has been less than 5000. The Province of Palencia does not have cities with more than 5000 people through which The French Way of Saint James passes, so it is exempt from this evaluation (Table 1).

Table 1. Cities with more than 5000 people in 2019 that are hosts of The French Way of Saint James in the Autonomous Community of Castilla y León (Spain).

Province of León	Province of Palencia	Province of Burgos
Astorga		Burgos
Cababelos		
León		
Ponferrada		
Valverde de la Virgen		

With the tools provided by the SUA, it is possible to territorialize and localize the commitments and challenges that are promoted at the international level in terms of sustainable urban development, within the framework of the SDGs, to local areas. From the visibility of the diagnoses and results obtained, the analyzed cities are given a preponderant position as the main promoters of their own sustainable development individually or together (taking advantage of the existing link with The French Way of Saint James), starting from the identification of aspects that are in line (or not) with the contribution of urban sustainability, SDGs, and the Specific Objectives of the SUA.

Through the data provided by the SUA in the context of connection with the SDGs, the diagnosis and analysis of the cities allows the promotion of bottom-up actions. In addition, having a reflection of the status of cities in terms of urban sustainability is useful to coherently promote various development strategies and/or action plans that manage to contribute to greater current and future socio-environmental well-being.

2. The Host Cities of The French Way of Saint James (Camino de Santiago Francés) in Castilla y León

One of the peculiarities that Castilla y León presents is the importance that The Way of Saint James has for many cities and towns. The Way of Saint James is an element of identity that gives a sense of belonging to the people and acts as a link between cities and towns, making them part of the same territorial-cultural system. In addition, Castilla y León is one of the areas most affected by depopulation in southern Europe [15] due to its greater agrarian tradition and the smaller initial size of its population centers [16].

The Way of Saint James is much more than a simple way. Hundreds of routes over eleven centuries have guided the journey of millions of people towards a particular meeting place: Santiago de Compostela in Galicia, Spain.

Today, the motivations of the people who travel the Way of Saint James are very diverse. Although, historically, the religious character has been highlighted as the main focus, nowadays, the Jacobean route has become a valuable tourist attraction, which pilgrims decide to travel to visit, as a traveler-tourist in general, the monuments and historical complexes, enjoy contact with well-cared-for nature and adequate accommodation, and even search for handcrafted souvenirs to take away [17]. There are as many routes as there are pilgrims to reach the Cathedral of Santiago de Compostela (Figure 2). However, The French Way of Saint James (Camino de Santiago Francés) is the best known, busiest, and best equipped route, which translates as the route preferred by the vast majority of pilgrims [18].

Figure 2. Cathedral of Santiago de Compostela in Galicia, Spain.

In Spain, from the Pyrenees (Roncesvalles) to Santiago de Compostela, The French Way has a length of approximately 750 km, which crosses five Spanish Autonomous Communities: Aragón, Navarra, La Rioja, Castilla y León, and Galicia [18]. Within the total distance covered by The French Way in Spain, approximately 400 km, more than half of the route, is in Castilla y León [19]. From east to west, the road passes through Castilla y León through three of its provinces: 112 km in the Burgos Province, 70 km in the Palencia Province, and 212 km in the León Province [19].

As part of the alternatives of the Jacobean route, it is noted that in Castilla y León, there are also other alternative ways: Silver Way (Camino Vía de la Plata), Portuguese Way (Camino Portugués), Mozárabe-Sanabrés Way (Camino Mozárabe-Sanabrés), Vía de Bayona Way (Camino Vía de Bayona), the Besaya Way (Camino del Besaya), Vadiniense Way (Camino Vadiniense), Salvador Way (Camino del Salvador), Madrid Way (Camino de Madrid), Levante and Sureste Way (Camino de Levante y Sureste), La Lana Way (Camino de La Lana), and Real de Invierno Way (Camino Real de Invierno).

The Way of Saint James in Castilla y León represents one of the greatest surprises offered to pilgrims, travelers, and tourists. The route stretches through fields, rises through mountains, and flows through rivers, which makes it an outstanding place due to its landscape and natural values. Today, while the natural route that is The Way of Saint James has rising value, the path, in its passage through this autonomous community, is a varied reflection of counties and a multicolored explosion of different spaces that allow an exceptional route [20]. In addition to its natural values, the Jacobean route in Castilla y León has a very rich artistic heritage, where the predominant style is Romanesque [20].

The Way of Saint James is very important for the survival and development of the cities and towns of Castilla y León. However, the reality of the provinces, cities, and towns of Castilla y León currently presents the social challenges of depopulation and aging [21]. This is a localized reality in Castilla y León because at the national level, in Spain, the population has tended to increase in recent years. Actually, politically and socially, it is even called "Castilla y León empty and/or emptied" [22].

Castilla y León is extremely rural: 2115 municipalities (94% of the total) have a population of less than 2000 people [15]. In total, 79.8% of the municipalities in Castilla y León do not exceed 100 people. Only 9 municipalities exceed 50,001 people, of which only 4 exceed 100,000 people [22]. Thus, depopulation has become a real problem of the state, which requires the implementation of innovative public policies aimed at boosting the local economy, providing basic and quality social services to rural areas [23].

Faced with this situation of rurality, intermediate cities acquire importance, considering that the concept of an "intermediate city" transcends the scope of spatial and population size to open new perspectives that modify the hierarchy of scalar analysis. This concept also includes the analysis of the economic, social, cultural, and environmental governance of cities that, due to their territorial implantation, have to play a key role in correcting inequalities derived from current urbanization, which is too focused on large cities [24]. The most holistic definition [25,26] is summarized below: (a) The intermediate city, beyond its demographic relevance, has the capacity to structure and unite the urban system and urban–rural links. Intermediate cities weave and work in networks. (b) The intermediate city, due to its scale, has a greater capacity to draw up and implement high-benefit strategies that allow it to position itself in regional, national, and even international scenarios, using fewer resources than large cities. (c) The intermediate city constitutes in itself a groundbreaking element of the status quo derived from the impact of globalization, since it contributes to questioning the hierarchies of the urban system, opening new horizons of territorial cooperation [24,27].

If we consider the host analyzed cities of Burgos, León, Ponferrada, Astorga, Valverde de la Virgen, and Cacabelos as intermediate cities, then they are cities with a remarkable potential for dynamism, which could experience growth in their population and activities [28]. However, when analyzing the population, Leon and Astorga have shown depopulation in recent years (Figure 3) while Ponferrada, Valverde de la Virgen, Burgos, and Cacabelos have shown population increases (Figure 4).

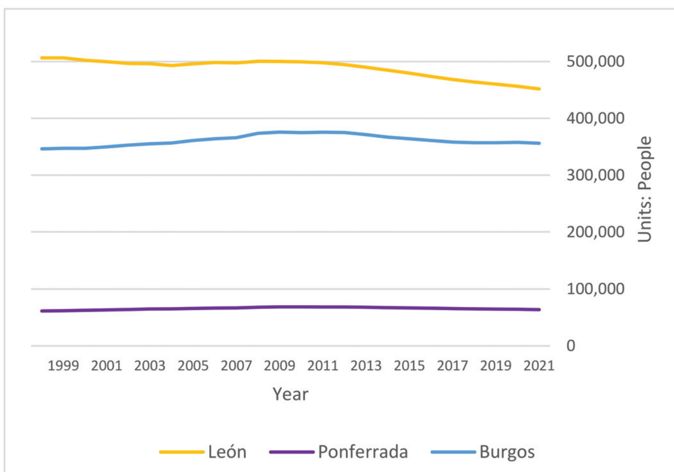

Figure 3. Population evolution in the cities of León, Burgos, and Ponferrada (1998–2021). Source: Own elaboration with data extracted from the INE website: www.ine.es (accessed on 15 July 2022) [21].

Taking into account that the cities analyzed share the passage of The Way of Saint James (host cities) and have more than 5000 people living there (at least for the year 2019), they have diverse characteristics:

- Burgos and León are provincial capitals and represent the upper segment of the urban centers of the Autonomous Community of Castilla y León [29]. They have more than 300,000 people.
- Ponferrada had 63,747 people in the year 2021 [30] and articulates large territorial areas. Together with Burgos and León, they are intermediate urban areas located in the northwest of the peninsula [28].
- Astorga, Cacabelos, and Valverde de la Virgen have fewer than 15,000 people and represent the smallest cities in this analysis. They have importance and transcendence within the province of León.

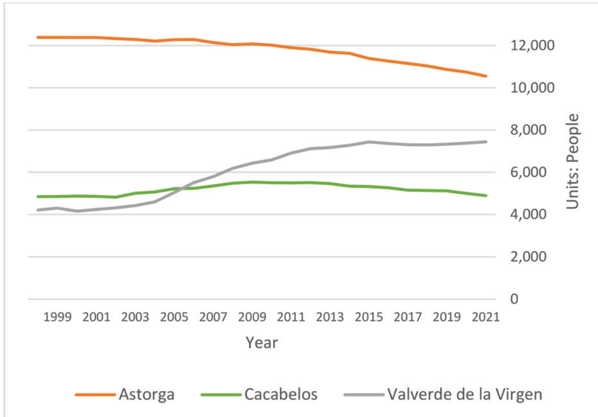

Figure 4. Population evolution in the cities of Astorga, Cacabelos, and Valverde de la Virgen (1998–2021). Source: Own elaboration with data extracted from the INE website: www.ine.es (accessed on 15 July 2022) [21].

In Spain, the presence of medium/intermediate cities is the real constitutive element of the urban network and one of the most important explanatory bases of the territorial structure of the country and they are the territorial labels of the "glocal" [28]. Considering that the cities mentioned are important for the development of the region, the search for urban sustainability, aligned with the cultural-territorial union of The Way of Saint James, is an alternative to promote joint territorial actions, action plans, and even receive EU aid that can bring economic, social, and environmental benefits for their future development.

3. The Challenge of the SDGs and the Implementation of Indicators at the Local Level

The literature on indicators in general, and the literature on indicators in urban contexts shows that sustainability indicators are used to monitor change in society and show progress towards a given goal or objective, based on observable or measurable markers [31–34]. Indeed, an indicator can be defined as an observable characteristic that is supposed to represent a generally unobservable state or trend at a given time [35,36].

In particular, the SDG indicators pose great challenges regarding their implementation at the local level [37]. Although they recognize the role of cities in sustainable development, the 2030 Agenda was agreed and signed by national governments. So, the territorialized implementation of its targets and indicators requires a process of adaptation and/or localization [38].

The challenges mentioned specifically refer to the availability and access of reliable, spatial, specific, standardized, open, comparable, measurable, and observable data at the urban level [38–44]. This is often framed by a lack of solid institutions dedicated to data collection at the city scale [44]. Therefore, the challenges of accessing the data located at the local level must include the selection of a set of limited indicators that manage to reflect aspects necessary to evaluate the sustainability of a city [42]. In addition, the data must necessarily be simplified for monitoring so that it can be replicated in several cities [43], which would allow cities to be compared based on the relevant evaluations.

In this context, SUA appears to be a very useful tool in this field since it transfers the urban goals of the SDGs of the 2030 Agenda, especially SDG 11, to the reality of towns and cities. The 17 SDGs are:

1. No poverty
2. Zero hunger
3. Good health and well-being
4. Quality education
5. Gender equality

6. Clean water and sanitation
7. Affordable and clean energy
8. Decent work and economic growth
9. Industry, innovation and infrastructure
10. Reduced inequalities
11. Sustainable cities and communities
12. Responsible consumption and production
13. Climate Action
14. Life below water
15. Life on land
16. Peace, justice and strong institutions
17. Partnerships for the goals.

The SUA even has its own objectives and indicators that are aligned with the goals of the 2030 Agenda, making it a practical tool for achieving the SDGs at the local level. As shown in Table 2, the SUA links each of its 10 Specific Objectives to the SDGs [45].

Table 2. Relationship of each Specific Objective of the SUA with the SDGs.

Specific Objective SUA	Linked SDGs
1. Organize the territory and make rational use of the land, conserve and protect it	2; 6; 11; 14; 15
2. Avoid urban sprawl and revitalize the existing city	1; 4; 11
3. Prevent and reduce the impacts of climate change and improve resilience	1; 3; 11; 13
4. Make sustainable management of resources and favor the circular economy	6; 7; 11; 12
5. Promote proximity and sustainable mobility	3; 9; 11
6. Promote social cohesion and seek equity	1; 4; 5; 10; 11
7. Promote and favor the Urban Economy	1; 2; 5; 8; 9; 12
8. Guarantee access to Housing	11
9. Lead and foster digital innovation	5; 9
10. Improve intervention instruments and governance	4; 11; 12; 16; 17

Using data from an official government source such as the SUA and its consequent reflection of urban realities is what this research carries out. As increasingly more guidance is available on the localization of the SDGs [42,46,47] and research that highlights the challenges in implementing the SDGs at the local level, it is vital and necessary to acquire experiences to be able to work with the SDGs in practice and make them a tool to achieve sustainable development [42].

This article reflects the situations of the evaluated cities in achieving sustainable development and the Specific Objectives of the SUA, thus the SDGs, are identified. Based on the results obtained, cities have the capacity to influence local and regional conditions through policy intervention [48] in planning and decision-making, in creating awareness, in the encouragement of behavior, in the promotion of public participation [44], and in alignment with the SDGs. In any case, the realities of urban sustainability in a particular region that needs to become strong, unite, and work together for current and future problems and challenges are discovered and made visible.

4. Materials and Methods

4.1. Data Selection

Given the need to count and select quantitative, locally applicable, statistically comparable indicators from official sources, the SUA Descriptive Data was selected. They are related to the ten Specific Objectives that the SUA has.

Access to the SUA Database is free on the Spanish Urban Agenda website [3]. The Database has a table that collects information available from all the Spanish municipalities, with more than 50 descriptive data on the SUA, and another table in which the data corresponding to the first quartile, the median value, and the third quartile are offered according to the cluster by population size: municipalities with more than 100,000 people, municipalities with between 50,000 and 100,000, between 20,000 and 50,000, between 5000 and 20,000 people, and municipalities with less than 5000 people. This database of over 200,000 data allows not only for data related to a one municipality to be obtained but also to make a comparison with municipalities with similar characteristics, such as the population.

Regarding the sources of information used to calculate the SUA Descriptive Database, the most recent data possible was used. These data can be requested from the Ministry of Transport, Mobility and Urban Agenda of the Government of Spain, and obtaining them facilitates an approximation to the current situation of each Spanish cities, configuring itself as a useful tool for decision-making and the establishment of specific goals to be achieved.

For the realization of this article, values were extracted (in July 2021) from the SUA Database and those that correspond to the cities of Castilla y León related to The French Way of Saint James were selected: Astorga, Cacabelos, León, Ponferrada, and Valverde de la Virgen (province of León) and the city of Burgos (province of Burgos). Of the 72 descriptive data made possible by the SUA Database, a total of 49 were considered for the analysis (Table 3). The rest of data was not available or did not indicate quantitative data to be analyzed, as is the case, for example, of the indicators D.38 and D.39 ("Date of the current urban planning figure in the municipality" and "Agenda Planning, Strategic Planning and Smart Cities", respectively).

Each of the SUA databases used, with its definition, relevance, and calculation methodology according to the SUA, are described in the document "Descriptive Data of the Spanish Urban Agenda" available on the SUA's web platform.

4.2. Data Normalization

The analysis carried out was located in places that, in addition to their geographical proximity, belong to the same Autonomous Community. Its relationship with The French Way of Saint James and its main distinctive characteristics are described in Section 2.

To make the cities comparable with the data and indicators provided by the SUA, they were reduced to a predominant non-dimensional unit for which the normalization method was used through the minimum-maximum index. Once the descriptive data of the SUA was collected, first, and following the steps considered by Nagy et al., 2018 [49], each of the variables was normalized on a scale of 0 to 10, where 0 indicates the worst performance and 10 the best performance. To eliminate the effect of extreme values, the lower and upper limits of each indicator were identified in each of the cities analyzed, and then the minimum-maximum method [50] was used, which makes it possible to create a range from 0 to 10.

Considering the main criteria of the New Urban Agenda [51], for some indicators (such as indicator D.05. "Green areas per 1000 people"), the high value score was considered to represent a good performance in terms of sustainability, marked as $\hat{x}$ in Table 3, and for others, it was considered that it represented a poor performance (such as indicator D.02.a. "Artificial coverage area by municipality"), marked as $\check{x}$ in Table 3. Therefore, the formulas were applied inversely depending on the attributes and thus also ensures that higher values represent better performance:

$$\hat{x} = \left(\frac{x - min(x)}{max(x) - min(x)}\right) * 10$$

$$\check{x} = \left(\frac{max(x) - x}{max(x) - min(x)}\right) * 10$$

where x is the raw data value; $min(x)$ and $max(x)$ determine the lower and upper limits for the worst and best performance, respectively; and $\hat{x}$ / $\check{x}$ is the normalized value after the rescaling process.

Table 3. Descriptive data of the SUA considered for the analysis.

SUA Indicator	Source	Specific Objectives SUA	Max. Value	Min. Value
D.01. Population variation 2007–2017 (%)	INE	1; 2; 3; 4; 5; 6; 7; 8; 9; 10	12.1 ($\hat{x}$)	−10.6
D.02.a. Artificial coverage area by municipality (%).	CORINE	1; 3	52.4	4.9 ($\check{x}$)
D.02.b. Crop area by municipality (%).	SIOSE	1; 3	45.8 ($\hat{x}$)	7.8
D.02.d. Forest and meadows areas by municipality (%).	SIOSE	1; 3	78.3 ($\hat{x}$)	18.0
D.03.a. Municipal surface destined to agricultural and forest exploitations (%).	SIOSE	1; 3	0.4 ($\hat{x}$)	0.0
D.03.b. Surface destined to agricultural and forest exploitations with respect to the urban land and urbanizable delimited of the city (%).	SIOSE/SIU	1; 3	5.6 ($\hat{x}$)	0.0
D.04. Municipal area of undeveloped land (%).	SIU	1; 10	93.6 ($\hat{x}$)	27.6
D.05. Green areas per 1000 people.	SIOSE/INE	1; 3	20.4 ($\hat{x}$)	2.1
D.06. Urban density. Number of people per hectare of urban land surface (people/ha)	INE/SIU	1; 2; 4; 5; 6; 7; 8; 9	85.3 ($\hat{x}$)	23.3
D.07. Area of discontinuous mixed urban land over total mixed urban land (%)	SIOSE 2009	1; 2; 5	47.4	6.2 ($\check{x}$)
D.08. Housing density by urban land area (Hou./ha).	INE_CENSO/SIU	1; 2; 4; 5; 6; 7; 8; 9	54.2 ($\hat{x}$)	14.5
D.09. Urban compactness. Total built area per floor area (m^2t/m^2s)	Catastro/SIU	2; 5; 6	1.0	0.4 ($\check{x}$)
D.10.a. Constructed area for residential use by land area (m^2t/m^2s)	Catastro/SIU	2; 5; 6	0.6	0.3 ($\check{x}$)
D.10.b. Built area for residential use with respect to the total built area (%).	Catastro/SIU	2; 5; 6	75.2 ($\hat{x}$)	43.3
D.ST.01. Expected housing in development land areas (Hou./ha).	SIU	2; 5; 6; 8	63.3 ($\hat{x}$)	17.8
D.ST.02. Percentage of development land areas with respect to the total urban land (%)	SIU	1; 2; 10	94.3 ($\hat{x}$)	2.0
D.ST.03. Developable land delimited with respect to the total urban land (%)	SIU	1; 2; 10	66.0 ($\hat{x}$)	2.0
D.ST.04. Percentage of land areas under development for residential use with respect to the total urban land (%).	SIU	1; 2	66.5 ($\hat{x}$)	1.5
D.ST.05. Percentage of land areas under development used for economic activities (industrial or tertiary) with respect to the total urban land (%).	SIU	1; 2; 6; 7	27.8 ($\hat{x}$)	0.0
D.14. Percentage of the building stock by municipality that was older than the year 2000 (%).	Catastro	2; 3; 4	71.5	36.6 ($\check{x}$)
D.17.a. Transport infrastructure area (ha).	SIOSE	1; 5	538.1 ($\hat{x}$)	1.1
D.17.b. Percentage of surface of transport infrastructures with respect to the municipal term (%)	SIOSE	1; 5	5.4 ($\hat{x}$)	0.0
D.18.a. Residential vehicles per 1000 people.	DGT	3; 5	621.1	506.0 ($\check{x}$)
D.18.b. Percentage of passenger cars (%)	DGT	3; 5	78.2	70.1 ($\check{x}$)
D.18.c. Percentage of motorcycles (%)	DGT	3; 5	8.2	6.7 ($\check{x}$)
D.22.a. Population aging index (%)	INE	2; 5; 6; 7; 8; 9; 10	25.4	14.3 ($\check{x}$)
D.22.b. Population senescence index (%)	INE	2; 5; 6; 7; 8; 9; 10	18.3	12.0 ($\check{x}$)
D.23. Percentage of foreign population (%)	INE	2; 6; 7	7.5 ($\hat{x}$)	3.0
D.24.a. Total Dependency Index (%)	INE	2; 6; 7	61.3	43.8 ($\check{x}$)
D.24.b. Child dependency ratio (%)	INE	2; 6; 7	23.0	18.4 ($\check{x}$)

Table 3. *Cont.*

SUA Indicator	Source	Specific Objectives SUA	Max. Value	Min. Value
D.24.c. Elderly dependency ratio (%)	INE	2; 6; 7	47.3	23.2 ($\check{x}$)
D.26.a. Workers in the agricultural sector (%).	INE	6; 7	7.8 ($\hat{x}$)	0.9
D.26.b. Workers in the industrial sector (%).	INE	6; 7	20.1 ($\hat{x}$)	5.7
D.26.c. Workers in the construction sector (%).	INE	6; 7	10.5 ($\hat{x}$)	4.5
D.26.d. Workers in the service sector (%).	INE	6; 7	89.0 ($\hat{x}$)	68.1
D.27.a. Establishments in the agricultural sector (%).	INE	7; 9	8.2 ($\hat{x}$)	0.1
D.27.b. Establishments in the industrial sector (%).	INE	7; 9	13.0 ($\hat{x}$)	3.2
D.27.c. Establishments in the construction sector (%).	INE	7; 9	11.0 ($\hat{x}$)	5.3
D.27.d. Establishments in the service sector (%).	INE	7; 9	91.3 ($\hat{x}$)	71.2
D.28.a. Total percentage of unemployed (%).	INE	6; 7	16.0	10.0 ($\check{x}$)
D.28.b. Percentage of unemployed between 25–44 years (%)	INE	6; 7	46.7	37.4 ($\check{x}$)
D.28.c. Female unemployment rate (%)	INE	6; 7	58.4	55.7 ($\check{x}$)
D.29. Number of households per 1000 people.	INE	2; 8	677.7 ($\hat{x}$)	522.3
D.32. Variation in the number of households 2001–2011 (%)	INE_Censo	1; 2; 8	91.5 ($\hat{x}$)	8.9
D.33. Growth of the housing stock 2001–2011 (%)	INE_Censo	1; 2; 4; 8	85.0 ($\hat{x}$)	12.9
D.34. Percentage of secondary households (%).	INE_Censo	2; 8	13.9 ($\hat{x}$)	6.2
D.35. Percentage of empty housing (%).	INE_Censo	2; 8	23.8	15.2 ($\check{x}$)
D.ST.06. Percentage of homes planned in development areas with respect to the existing housing stock (%)	SIU/INE_Censo	1; 2; 4; 8	66.4 ($\hat{x}$)	2.2
D.ST.07. Number of homes planned in the development areas per 1000 people.	SIU/INE	1; 2; 4; 8	386.2 ($\hat{x}$)	14.9

Through normalization, the data became easily comparable between all the indicators. Therefore, values were obtained for each of the cities analyzed according to each of the 10 Specific Objectives of the SUA (mentioned in the Table 2). Using the arithmetic mean method using the values described, a general value per city was obtained and normalized on a scale of 0 to 10 according to its particular contribution to the SUA Objectives and, therefore, according to urban sustainability.

In Table 3, the indicators, the source, and the relationship with the Specific Objectives of the SUA are displayed. In addition, the maximum and minimum values of the group of cities analyzed without their respective normalization are revealed, in such a way that they serve as a reference framework to consider the ranges of real values that are handled between the cities of Astorga, Cacabelos, León, Ponferrada, Valverde de la Virgen, and Burgos.

5. Results

This research analysis focused on the urban sustainability of the host cities of The French Way of Saint James in Castilla y León, which in 2019 had more than 5000 people. The data provided by the SUA and each of the selected indicators (Table 3), considering their scores with the values already normalized and weighted for each city in the range of 0–10, allow us to identify and diagnose the situation of the cities according to the 10 objectives specific to the SUA and, therefore, to the SDGs (Table 2).

In this way, by analyzing the scores of each one of the indicators by the host city, grouped in the 10 Specific Objectives of the SUA, general values were obtained (Table 4).

According to the general values obtained, the city of Valverde de la Virgen has the best performance in terms of sustainability. Valverde de la Virgen also presents the best values in 9 of the 10 Specific Objectives of the SUA. In descending order, are the cities of León and Burgos, which present similar general values between them. Then, there is the city of

Ponferrada, which is the predecessor of the worst performers found in terms of general urban sustainability, visible in the cities of Cacabelos and Astorga, respectively (Figure 5).

Table 4. Results of the values referring to urban sustainability in the host cities, which were analyzed according to the Specific Objectives of the SUA.

City	Specific Objectives of the SUA										General Value
	1	2	3	4	5	6	7	8	9	10	
Burgos	4.3	4.4	3.8	3.1	6.4	4.6	4.7	4.0	4.3	5.7	**4.6**
Astorga	3.8	2.9	4.6	0.7	3.3	3.6	3.3	2.4	2.9	2.7	**3.0**
Cacabelos	2.2	2.7	4.5	1.2	4.1	4.4	3.5	1.9	4.1	2.3	**3.1**
León	5.3	5.4	1.7	5.7	5.1	4.5	4.5	5.3	3.7	6.0	**4.7**
Ponferrada	3.4	4.3	3.9	3.0	4.3	4.7	4.1	4.0	3.5	4.1	**3.9**
Valverde de la Virgen	6.6	6.3	5.1	7.4	5.0	4.7	4.7	6.3	5.3	7.1	**5.9**

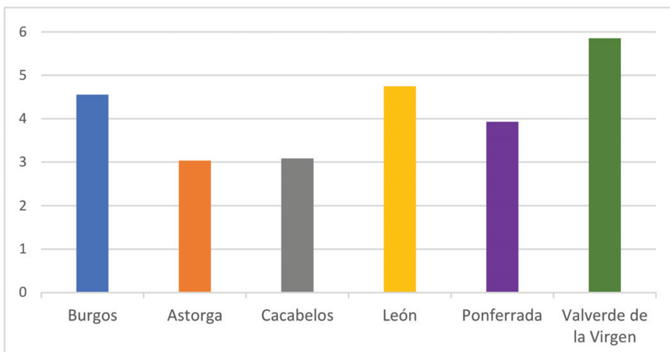

Figure 5. General values of the urban sustainability in the host cities of The French Way of Saint James in Castilla y León.

In detail, for each of the cities analyzed, Valverde de la Virgen has the best performance in all the Objectives (1; 2; 3; 4; 6; 7; 8; 9; and 10) compared to the other cities, with the sole exception of Objective 5. Its particular performance stands out in Specific Objective 4 "Make sustainable management of resources and favor the circular economy" and in Objective 10 "Improve intervention instruments and governance". In Specific Objectives 6 "Promote social cohesion and seek equity" and 7 "Promote and favor the Urban Economy", it is also a leader, but in this case, it shares its leadership with Ponferrada and Burgos, respectively. Continuing with the comparison, it is identified that the only Objective that the city of Valverde de la Virgen is surpassed is in Objective 5 "Promote proximity and sustainable mobility", where the cities of Burgos and León have the best diagnoses (Figure 6). Even in Objective 5, Valverde de la Virgen presented the lowest values and, therefore, the worst performance.

Following the leadership of Valverde de la Virgen, we visualized a group of cities composed of León and Burgos, which reflects their general values in terms of sustainability in a fairly similar way.

León is surpassed by Valverde de la Virgen in the Specific Objective 1 "Organize the territory and make rational use of the land, conserve and protect it", Objective 2 "Avoid urban sprawl and revitalize the existing city", Objective 4 "Make sustainable management of resources and promote the circular economy", and Objective 8 "Guarantee access to Housing". It is only surpassed by Burgos in Specific Objective 5, referring to "Promote proximity and sustainable mobility". However, there are no cities that present lower values than León in Specific Objective 3 regarding adaptation and resilience to climate change; therefore, the less favorable position in this particular aspect is attributed.

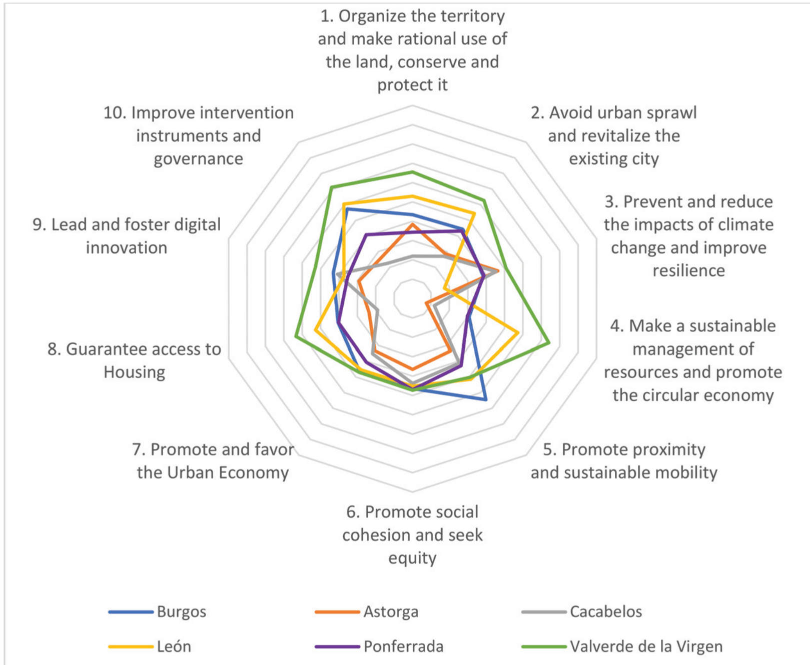

Figure 6. Radio visibility of the contribution to urban sustainability by city according to the Specific Objectives of the SUA.

Burgos, on the other hand, stands out as being the best city in the Specific Objective 5 regarding sustainable mobility and, together with Valverde de la Virgen, they present the best values in Objective 7 regarding urban economy. Without taking into account the comparison with the other cities, the values of Burgos appear quite uniform according to all the Specific Objectives of the SUA, where its best version is found in Objective 5 and its most unfavorable value in Objective 4 "Make sustainable management of resources and favor the circular economy".

Comparing the city of Ponferrada with the other cities, it is possible to observe that its position in fourth place, according to the general value obtained, represents and justifies its detailed analysis and comparison for each of the Specific Objectives. In fact, Ponferrada is in fourth position in Specific Objectives 2, 3, 4, 5, 7, 8 (with Burgos), 9, and 10. Undoubtedly, the particularity and the aspect to highlight of Ponferrada is there is no other city that surpasses it in its contribution towards Specific Objective 6, referring to "Promote social cohesion and seek equity". Viewing only the values relevant to Ponferrada, it is observed that its worst performance is shown under Objective 4 "Make sustainable management of resources and favor the circular economy".

The cities of Cacabelos and Astorga are the cities with the worst numbers in terms of the general values according to their contribution to the Specific Objectives defined by the SUA.

Compared to the other cities, Cacabelos presents the lowest values in compliance with Specific Objectives 1, 2, 8, and 10. In addition, it is in the penultimate place in its contribution towards Specific Objectives 4, 5, 6, and 7. Leaving aside the comparison, the worst value of Cacabelos is framed under Specific Objective 4, referring to "Make sustainable management of resources and promote the circular economy", and its best version is found in Specific Objective 3, regarding prevention, anticipation, and adaptation strategies to climate change.

For its part, the city of Astorga justifies its last position in terms of urban sustainability in this comparison of cities, since it shows the worst values in Specific Objectives 4, 5, 6, 7, and 9 and second to last in the values of Objectives 1, 2, 8, and 10. The city of Astorga is in second position, just behind Valverde de la Virgen, referring to its adaptive management of climate change, without a doubt the greatest aspect that contributes to its own urban sustainability. On the contrary, its diagnosis regarding the sustainable management of resources and the promotion of the circular economy shows the lowest value of all those presented by the other cities.

6. Discussion and Conclusions

This article used the data provided by the SUA to overcome the barriers and challenges that are usually found when trying to locate and territorialize the SDGs at the local level. The availability of reliable, quantifiable, and updated data, which serve as indicators, makes it possible to work with the SUA itself, giving it greater visibility and significance, in addition to stimulating progress "from the bottom up", considering cities as fundamental engines of change in terms of sustainability and the labels of the "glocal".

Understanding that the SDGs are more general and global objectives, their location and territorialization was carried out in this case by evaluating the Specific Objectives of the SUA, a document directly related to the 2030 Agenda due to its origin, nature, and objectives pursued. This work highlights the ability of the SUA to reflect the urban realities of Spanish towns and cities and to reflect their contributions towards sustainable development and the SDGs. In this case, host cities of Castilla y León, linked to The French Way of Saint James, were analyzed.

The results of the diagnosis of the cities of Valverde de la Virgen, León, Burgos, Ponferrada, and Cacabelos allowed the identification of four marked groups in reference to the state of the situation of sustainable development.

In the evaluation conducted, it is highlighted that the city of Valverde de la Virgen has the conditions and the support to lead other cities in terms of urban sustainability, a fact that perhaps its own authorities are unaware of. Especially, Valverde de la Virgen could lead and serve as an example of urban sustainability for small cities in the region such as Cacabelos and Astorga. Therefore, the analysis carried out thus gives it a very prominent role in the post of urban sustainability and even the city itself could cling to it, using it as a communication strategy to, for example, promote the passage of tourists who travel The French Way of Saint James through a "sustainable city". The good condition that Valverde de la Virgen presents in terms of sustainability is a great strength, considering the increase in population that it has experienced in recent years. In reference to this, it could improve its behavior in mobility and digital innovation since these are essential issues for a good-quality urban life in these times.

León and Burgos, beyond their geographical distance and belonging to different provinces, reflect a good performance in terms of sustainability with similar contributions towards sustainable development. These cities, given that both are capitals of their respective provinces and have more than 350,000 people, could also even be provincial, Autonomous Community, and The Way of Saint James benchmarks in terms of sustainability, and even work together to guide sustainable development at the regional level. In a potential joint effort for their sustainable development, León could learn from Burgos issues on sustainable mobility and climate change while Burgos could learn from León issues on resource management, circular economy, and access to housing such as urban land use. Since they are cities with a lot of weight in the development of the Autonomous Community, together, they have great potential to request aid for sustainability (for example, for climate change issues) from the Autonomous Community itself, the Government of Spain, and even the EU.

Ponferrada stands out as a city with uniform parameters. However, it could increase its efforts and ambitions to achieve a better performance. It is recommended that it aligns and works together with the cities that stand out the most in this regard, mainly with

León and Burgos due to their population sizes. With similar parameters considering the contributions towards the Specific Objectives of the SUA, the local administration presents the opportunity to define, based on the diagnosis, where to particularly focus the greatest efforts and action plans. However, it is recommended to promote actions in innovation, resource management, and the circular economy.

Both Cacabelos and Astorga are disadvantaged by the analysis carried out. Therefore, they are the cities that must begin to work more decisively in the search for urban sustainability so that they can guarantee a greater state of social, economic, and environmental well-being for their citizens, tourists, and biodiversity in general. The most disadvantaged position of these cities can also be taken to attract financing that motivates the implementation of ambitious and urgent action plans. It is recommended that they follow the exemplary performances of Valverde de la Virgen to identify and improve their good performances, replicate them, and work together.

Considering the general analysis of the cities, only Valverde de la Virgen exceeded 5 points on the 0–10 scale. In other words, these host cities are not in a very privileged position in terms of urban sustainability. This situation results in the thought and reflection that there is still much to be achieved for urban areas to contribute efficiently to the goals of the 2030 Agenda and the SDGs. In the case where the cities on The French Way of Saint James in Castilla y León were analyzed have to focus jointly on some interventions and action plans in particular, and the results have shown the need to act to increase resilience against the impacts of climate change and improve the sustainable management of resources. For the relationship between climate change and The French Way of Saint James in Castilla y León, climatic conditions with decreased rainfall and increased temperatures are projected. This has the potential to affect the seasonality of visits, the health of pilgrims, the conditions of public services in cities and towns, and even the cultural heritage [52]. Regarding resource management, a circular model of landscape resource regeneration can, therefore, contribute to the reconstruction of local economies. In small towns and in the innermost territories, where depopulation and human dynamics affect the quality of the landscape and elements of vitality persist, regenerative models of resources inspired by circular economic systems, such as slow tourism, can be applied with greater ease [53]. On the other hand, this set of cities shows its best performance in terms of sustainable mobility and intervention and governance instruments. Another important point that emerges from the joint analysis of the cities is the high degree of diversification and heterogeneity of the municipalities in relation to sustainability.

If the results are analyzed by differentiating two groups of cities, understanding that the present behaviors, resources, and realities of León, Burgos, and Ponferrada (larger cities) are different from Cacabelos, Astorga, and Valverde de la Virgen (smaller cities), especially due to the size of their populations, we find the following behaviors: larger cities have a better urban sustainability performance compared to small cities. This was evidenced in 8 of the 10 Goals (1, 2, 4, 5, 6, 7, 8, 9, 10). However, small cities, as a whole, present better performances in Objective 3 and 9 regarding climate change and innovation, respectively. This is mainly justified by the high values obtained by Valverde de la Virgen, since they are results, at least, that attract attention. Above all and especially, they draw attention to the issue of innovation since a great challenge and problem that the smaller towns and cities of Castilla y León have is their lack of connectivity and innovation.

The activity and the results obtained are useful since they can be part of a management tool that supports the prioritization of local and/or regional policy interventions based on reliable, verifiable, and up-to-date data. In addition, this article helps to improve the actions of The Way of Saint James and the relationships between cities and towns, as the Spanish Federation of Associations of Friends of The Way of Saint James demonstrates. This article stimulates the opportunity of local governments to implement local urban agendas, integrate urban policies, accelerate bottom-up actions, and establish innovative public policies, potentially linked by their synergy with The Way of Saint James. Its greatest weakness is that the implementation of concrete actions depends on political will and even financial aid.

Considering the establishment of urban sustainability, the 2030 Agenda and the SDGs on The Way of Saint James as a development alternative can bring with them an opportunity to lead a paradigm shift in a group of cities (and also towns) that face great challenges at the local and regional level. The link, and the knowledge that they are working with the SDGs and the 2030 Agenda, generates the potential opportunity to obtain aid and subsidies (from interested companies, the European Union, or the Spanish government, for example) to execute action plans, with support based on the UAE, which is reliable for measuring progress and following up with updated data. The historical–traditional relationship that the analyzed cities from The French Way of Saint James present in this case in its passage through Castilla y León, in addition to delimiting the scope of the investigation, provides the possibility of strengthening existing alliances (Spanish Federation of Associations of Friends of The Way of Saint James) and promoting new ones. Although the definition and measurement of sustainability is a complex and debatable issue, the work places it at the center of the scene. What is not debatable is that cities must work more ambitiously in search of sustainable development and having a reliable diagnosis, as reflected in this article, is the central tool to direct interventions and monitor them with the passage of time (especially useful for smaller cities).

Future research could even use the method developed in this article with new data from the Spanish Urban Agenda, post-2022, so that the impacts of COVID-19 on the sustainable development of the analyzed cities are known. The monitoring of urban sustainability over time is a great tool for observing how cities are developing, how they are growing (or decreasing), and where the main weakness in their progress is. In addition, the SUA itself also makes it possible to compare the cities of The French Way of Saint James in Castilla y León with the cities of The French Way of Saint James in other Autonomous Communities such as Aragón, Navarra, La Rioja, or Galicia, for example, organizing the results by city (as in this case) or by Autonomous Communities.

The measures of change for a better sustainable performance of the cities analyzed must be based on the cultural-territorial union of the cities themselves with The Way of Saint James. In this way, by acting together, they can help each other by taking exemplary cases, transmitting knowledge and actions, and, above all, requesting help from various governmental or non-governmental organizations to apply them in a timely manner in specific action plans. Likewise, these cities must support and guide the towns on The Way of Saint James in Castilla and León, which depend largely on the passage of tourists, and which currently suffer from serious problems such as depopulation, aging, and lack of services, among others.

This research facilitates the debate on the progress and advancement of urban sustainability and the SDGs, stimulates research on the subject, promotes citizen awareness and participation from academic environments, and even engages local and regional authorities in the search for cities that are prepared for greater social welfare. For additional information on the subject see Supplementary Materials.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14159164/s1, Additional information on the subject can be found in the UVa Master's Thesis: "El camino hacia los ODS—Metodología para la localización de los objetivos de desarrollo sostenible en las ciudades y pueblos del Camino de Santiago" publicly available here. https://uvadoc.uva.es/handle/10324/45282?locale-attribute=es (accessed on 1 June 2022). The mentioned Master's Thesis has been recognized by the UVa with the Extraordinary End-of-Master Award.

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Article

Diversification of Villa-Type Neighborhoods and Its Impact on Housing Shortages in a Growing Saudi Arabian City: A Case Study of Jeddah

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Abstract: During the urbanization process in Jeddah, evidenced by an annual population growth rate of 9.5%, vacant lots have existed in developed residential areas in spite of the housing shortage. This study aimed at investigating the housing shortage problem and suggesting future solutions based on a predictive formula through four tasks: (1) examining the issues induced by population growth; (2) assessing the extent to which articles in the Procedure Manual for Preparation of Residential Land Subdivision (PMPRLS) foster diversity within villa-type neighborhoods; (3) clarifying the extent of the applicability of these articles and the contribution of existing neighborhood patterns to the housing shortage problem; and (4) providing recommendations for developing each kind of villa-type neighborhood to contribute to resolving the housing shortage. The proposed development methods for villa-type neighborhoods were derived from a correlation analysis using PMPRLS-related indicators in all such neighborhoods (103 study sites) in Jeddah and from a predictive regression analysis. This study suggests that each neighborhood class can contribute to resolving the housing shortage problem. In conclusion, diversifying lot areas, population density, and lot widths in current villa-type neighborhoods would have a positive impact on the housing shortage problem.

Keywords: new development; street area; street length; lot area; lot proportion; lot price; housing expansion; low-density neighborhoods; middle-income residents; unplanned settlements

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1. Introduction

1.1. Research Background

The problem of housing shortages is a major issue that has spread globally as urbanization has accelerated since the Industrial Revolution. Over time, this issue has changed to encompass many aspects. In the 1980s, the housing problems in the major cities of Germany, which is now considered to be a developed country, were discussed [1]. Even during this period, the lack of social housing and the imbalance in housing supply due to disparities in poverty and wealth were seen as problems. These characteristics have also been cited as common issues in developing countries, which have urbanized in recent years due to population growth. Several studies have been undertaken in India related to the problem of housing shortages. In Delhi, Abhay [2], while presenting the number of houses built in the recent decade (2001–2011), pointed out that, although the housing supply is stimulated by the housing shortage problem, low-quality housing is widespread. Kumar [3] pointed out that the large number of obsolescent houses is a fundamental problem that leads to housing shortages. He suggested that important measures in solving the housing shortage problem are improving the quality of housing through taxation or incentive polices for vacant houses, and making these houses usable and selling them. That is, although the supply of housing is important, it should be incorporated with the supply of housing to ensure peoples' quality of life.

In recent years, the problem of housing shortages in developed countries having relatively high urbanization has occurred at the regional level, rather than in entire countries, due to land prices and housing construction costs. The relatively high cost of housing is a major issue in Silicon Valley, USA, and Gabbe [4] examined whether administrative re-zoning planning would be effective. Tian [5] also summarized the relationship between land supply and land prices for four Chinese mega-cities, and pointed out that, even if rental housing is supplied, it does not contribute to addressing the housing shortage problem due to urban land monopolies. Thus, the circumstances regarding housing shortages differ from period to period and from country to country, and solutions must be considered in accordance with these differences.

A major difference regarding the housing supply in Jeddah is that the city has an Islamic culture. Sulf [6] proposed design requirements for housing in Saudi Arabia consistent with Islamic culture, in response to the worsening housing shortage due to population growth, in addition to low-cost housing for middle- and low-income people. Regarding housing development in Jeddah, it is necessary to closely examine how to solve the housing shortage problem associated with rapid population growth in terms of the formation of neighborhoods centered on mosques.

Hegazy [7] also evaluated urban development in Jeddah in terms of sustainable urban management. He criticized Jeddah's lack of planning tools for managing the total urban planning system and controlling illegal development, and emphasized a more integrated development management system. In this regard, it is deemed timely and appropriate to address the housing supply issue based on Jeddah's housing planning tool, the Procedure Manual for the Preparation of Residential Land Subdivision (PMPRLS). Mulliner [8] noted that Saudi Arabia is suffering from a housing shortage, and highlighted the gap between consumers' preferences and practitioners' preferences in the movement toward providing large quantities of housing on a shorter-term basis. This indicates the importance of diversity in housing attributes. Therefore, it is necessary to evaluate whether housing developed according to the PMPRLS in Jeddah would ensure a diversification of housing attributes.

1.2. Research Area

Jeddah, one of Saudi Arabia's most traditional and rapidly growing cities, was founded as a fishing settlement 2500 years ago. From 1509 to 1947, Jeddah was walled. However, in 1947, the city wall was removed by the government because of the city's rapid expansion, which can be attributed to two main factors. The first is population growth, fueled by immigration from across the country, and the second is the importance of the city location as a gate for the two holy cities, Makkah and Madinah. From 1947 to 1987, the annual population growth rate averaged 9.5% [9]. According to the strategic plan issued by the Jeddah Municipality in 2009, Jeddah's population was estimated to grow by around 2.25 million people between 2007 and 2029 [9].

During the urbanization process that occurred between 1947 and 1980, unplanned settlements arose (Figure 1) because of the lack of adequate housing for low- and middle-income residents [9]. Subsequently, from 1992 to 2007, the increasing gravity of the housing shortage problem in Jeddah led to an increase in the number of houses occupied by two generations (couples living with their parents), which accounted for 80,000 families, and in the number of families (151,600) living in reclaimed houses in unplanned settlements [9]. As declared by Jeddah's mayor in the strategic plan formulated in 2009, the city faces two main issues. The first is the need for new and adequate housing (approximately 283,000 housing units) to resolve the current housing shortage, and the second entails providing sufficient units to meet the projected housing demand between 2009 and 2029, which is approximately 670,000 units. Two-thirds of these units will be required for low-and middle-income residents. Therefore, in total, around 953,000 new units will be needed in Jeddah up to 2029 [9].

Figure 1. Unplanned settlement (Source: authors).

In Saudi Arabia, typical sites are characteristically family-oriented detached houses, referred to as villa-type housing (Figure 2). This pattern is reflected in contemporary neighborhoods in Saudi Arabian cities, which are dominated by large numbers of villas as opposed to apartment buildings. For instance, in 2019, in the administrative area of Alqaseem, villas comprised approximately 57.32% of residential buildings. Moreover, in the capital Al-Riyadh, villas comprise approximately 45.71% of residential buildings. However, in Jeddah, villas comprise only around 17% of the residential buildings in the city. In contrast to other administrative areas in Saudi Arabia, in the Makkah area, apartments comprise 63.38% of the total housing units (Figure 3), accounting for the highest proportion of apartment units compared with those in other administrative areas in Saudi Arabia [10]. The population density of villa-type neighborhoods varies between 15 and 70 persons/hectare, according to structural plans formulated for Jeddah. However, the population density in neighborhoods where apartments are dominant varies between 15 and 200 persons/hectare [11] (Table 1). According to the Procedure Manual for Preparation of Residential Land Subdivision (PMPRLS) issued by the Ministry of Municipal and Rural Affair and Housing (MoMaRAaH), the minimum area of a land lot for a villa should be 300 m^2 [12].

Figure 2. Villa-type neighborhood (Source: authors).

Figure 3. Apartment-type neighborhood (Source: authors).

Table 1. Population density characteristics for each type of residential area in each structural plan developed for Jeddah.

Structural Plans District Type	1st Structural Plan 1963	2nd Structural Plan 1973	3rd Structural Plan 1978	4th Structural Plan 1987	5th Structural Plan 2004
	Unit: People/Hectare				
Within an urbanized area	100–150	-			
Outside an urbanized area	50–100				
Large villa	-	15	-		
Villa		50	75	25	40–70
Apartment		15	175	150–200	90–200

1.3. Research Objectives

The above discussion highlights several issues, namely the housing shortage, an increasing population trend, with low- and middle-income residents accounting for two-thirds of the projected housing demand, and the growing trend toward apartment building development and its relation to land lot areas in the city's growth. Of these considerations, population density in villa-type neighborhoods and legislation on land adjustments are key. Thus, the specific objectives of this study are to identify the housing shortage problem and suggest future solutions based on a predictive formula. To be specific, the following four objectives were established:

1. Identify solutions to issues relating to Jeddah's population growth through a review and analysis of (a) the total housing shortage and projected demand, (b) factors responsible for the housing shortage problem, (c) the local government's housing policy and strategy, and (d) the actual status of population density within each district in Jeddah (Section 2);
2. Analyze articles of the PMPRLS and assess the extent to which they foster diversity in relation to land lot areas, total street length, numbers of villas, population density, and numbers of children's playgrounds in villa-type neighborhoods (Section 3);
3. Clarify the extent to which the articles in the PMPRLS are applicable to existing neighborhoods and the extent to which the patterns of contemporary neighborhoods can be seen as being part of the housing shortage problem (Section 4); and
4. Determine the compositional characteristics of the 103 sites by dividing them into groups according to several indicators, which are discussed in the following section on research methods. A further aim was to propose methods of developing each group as an initiative toward resolving the housing shortage problem (Section 5).

1.4. Research Methods

To accomplish the above-mentioned objectives, data were collected from several competent authorities. The methodology was sequentially performed as discussed below.

1.4.1. Issues Relating to the Housing Shortage and Projected Demand

We collected data from the Jeddah Strategic Plan that was issued by the Jeddah Municipality in 2009 in the following areas: the characteristics of each structural plan formulated for Jeddah [11]; the population size from 1992 up to the projected population in 2029 [9]; the extent and types of housing shortages in the city [9]; the ratio of parks to population density in each district in Jeddah [9]; and data from the Jeddah Without Slums Program (JWSP) [9]. We also collected data on financing economics, housing policies [9], and the legal framework. These data were integrated to obtain a wide-angle view of the precise factors that have led to the problem of Jeddah's housing shortage.

1.4.2. Planned Neighborhood Composition

We sought to formulate the composition of planned neighborhoods on the basis of several articles in the PMPRLS that was enacted by the MoMaRAaH. We analyzed the following main factors:

- The characteristics of elements of a neighborhood, such as the ratio of land use, streets, open spaces, and public land and how they have been combined together [12].
- As Saudi Arabia is an Islamic country where mosques are used five times a day, the mosques in several residential blocks are centrally located within a service area distance of 200 m, as noted in the PMPRLS. Therefore, we conceptualized the elements of a neighborhood by situating them within an area having a radius of 200 m from a centrally positioned mosque.
- We performed two verifications in the following cases: (1) where the total areas of streets (as shown in the PMPRLS) accounted for 20% of the total neighborhood area, and (2) when the minimum street width was 10 m (as shown in the PMPRLS). Subsequently, we determined how these conditions can affect the ratios of other elements, such as the total area of public facilities, the total street length, the number of villas, and population density.

1.4.3. Actual Conditions in Existing Villa-Type Planned Neighborhoods

The regulations of the PMPRLS were formulated considering mosques as the core structures located at the center of groups of residential blocks within catchment areas (service distances) with radiuses of 200 m. After a complete survey of mosques located in villa-type neighborhoods in Jeddah, all mosques, i.e., 103 sites, were identified. Several indicators of the areas surrounding each mosque (within a 200 m radius) were analyzed (Figure 4). Google Earth (Google Earth Version 7.1) and Jeddah AutoCAD (AutoCAD Version 20.0) File [13] were the primary sources used for this analysis to organize housing development characteristics and trends. Several elements were selected with reference to the PMPRLS and analyzed. The elements were spatially subdivided into private spaces (villas, commercial facilities, and office buildings) and public spaces (mosques, elementary schools, streets, and parks). An observational survey of Google Earth aerial photographs was used to determine the presence or absence of housing development and the size and shape of housing sites during an 8-year period from 2008 to 2016, in addition to the presence or absence of development of surrounding facilities and their characteristics. The observational survey was conducted in 2016, and the first year of aerial photography available at that time was 2008. Based on these, the following parameters were quantified.

In the case of private spaces, six parameters were analyzed: (1) numbers of villas in 2008 and 2016; (2) total areas of villas (average value, median value, minimum and maximum values, and the differences between them); (3) the minimum, maximum, and median values of the distance of the setbacks of existing villas and their proportions in relation to the lot length; (4) the number of villas facing 1, 2, 3, and 4 streets; (5) the average land value (per square meter in the Saudi Arabian Riyal (SAR)) [14]; and, finally, (6) the total area occupied by commercial facilities and office buildings.

Nine parameters were established for public space: (1) total street area; (2) total road length; (3) the road width (maximum and minimum values, the difference between them, and the median value); (4) the distance from a mosque to the nearest mosque; (5) the area of land occupied by a mosque; (6) the distance to the nearest elementary school; (7) the number of parks, and the distance to the nearest park and the park lot area; (8) the total area of the vacant lot; and (9) the total area for public facilities, and public parking.

In addition to the above-mentioned factors, two more factors were analyzed:

- The extent to which the PMPRLS is actually applied in villa-type neighborhoods in Jeddah;
- The extent to which existing villa-type neighborhoods can be part of the solution to the existing housing shortage if the same pattern of their development is maintained.

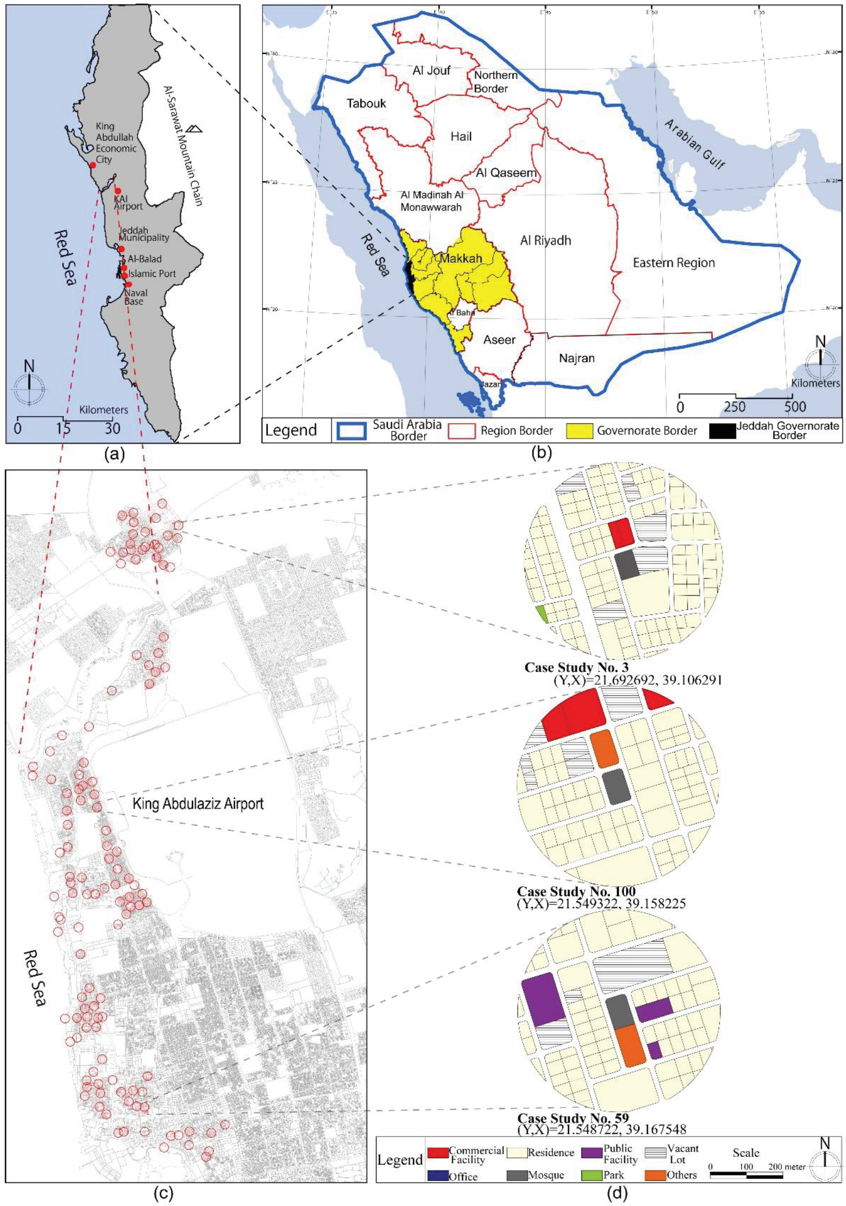

Figure 4. (**a**) The boundary of the Jeddah governate and the main landmarks (adapted by Rahif Maddah). (**b**) The national, regional, and governate boundaries in Saudi Arabia (adapted by Rahif Maddah). (**c**) The locations of the 103 study sites in Jeddah, shown as red circles [13]. (**d**) A sample of the study sites, each having a radius of 200 m [13] (adapted by Rahif Maddah).

1.4.4. Typology of Existing Villa-Type Neighborhoods and Proposals

A correlation analysis was conducted to clarify dependent factors in associated neighborhoods and, subsequently, to predict how villa-type neighborhoods evolved during the period 2008–2016. This analysis was performed using the parameters described in Section 1.4.3 and the numerical values of parameters described in Section 4, and by conducting a predictive multiple regression analysis. Contemporary villa-type neighborhoods were subsequently grouped together, and strategies were proposed for each group (Section 5).

1.5. Previous Studies

Several studies have been previously conducted on residential areas in Jeddah at planning scales ranging from architectural to city scales. Abu-Ghazzeh [15] explained the principal values of the Islamic faith and their effect on the structural development at the architectural scale, including in the historical area of Jeddah (Al-Balad). Salama [16] reviewed affordable housing in the city. Attia [17] suggested that the traditional housing technology of Jeddah will be effective in providing guidelines for a sustainable society in the future, since the housing technology has been built on historical experience and is suitable for the conservative Islamic society, and the building materials are also adapted to the climate characteristics. Jambi [18] conducted an online survey to identify factors that influence housing purchases by buyers, noting the importance of the closeness of the property to family members and the infrastructure of the district. The significance of this study is the approach taken to address the issue of the housing shortage, by clarifying the characteristics of the traditional housing style, villa-type housing, and the intentions of housing buyers based on past development trends.

Maddah conducted studies at an urban design scale, for example, on the usage of open space [19] and spatial configurations between residential buildings [20]. A study to evaluate walkability in villa-type neighborhoods in Jeddah was conducted by applying the HPE Walkability Index developed by Hall Planning & Engineering Inc. [21]. Mousalli [22] examined residential locations at a city scale. Al-Otaibi [23] used the market-based approach to evaluate the housing shortage crisis, and Murad [24] focused on commercial areas. Notably, none of the above-mentioned studies applied a multidimensional perspective to explore the housing shortage crisis. Such a perspective can be applied, for example, to the transition of the areas and shapes of residential lots, and to the relationship between land price and public spaces such as streets, parks, and mosques.

2. Housing Policies and Issues in Jeddah

2.1. The Housing Shortage and Projected Demand

In 2009, the Municipality of Jeddah released a strategic plan that revealed problems relating to the housing shortage and projected demand in Jeddah. Figure 5 shows that Jeddah has been experiencing a severe housing shortage since 1992, with a total requirement of 231,600 units, each accommodating an average of four persons per household, needing to be made available by 2009. Moreover, population growth between 2007 and 2009 resulted in an additional deficit of 51,500 units. Furthermore, the projected housing demand during the period 2009–2029 evidences variations every half-decade. On average, 33,500 units are required annually up to 2029 (Figure 5). However, because of the lack of data, we were not able to confirm the occurrence of (a) the shortage in housing units (1992–2009) and (b) the projected demand during the period 2009–2021.

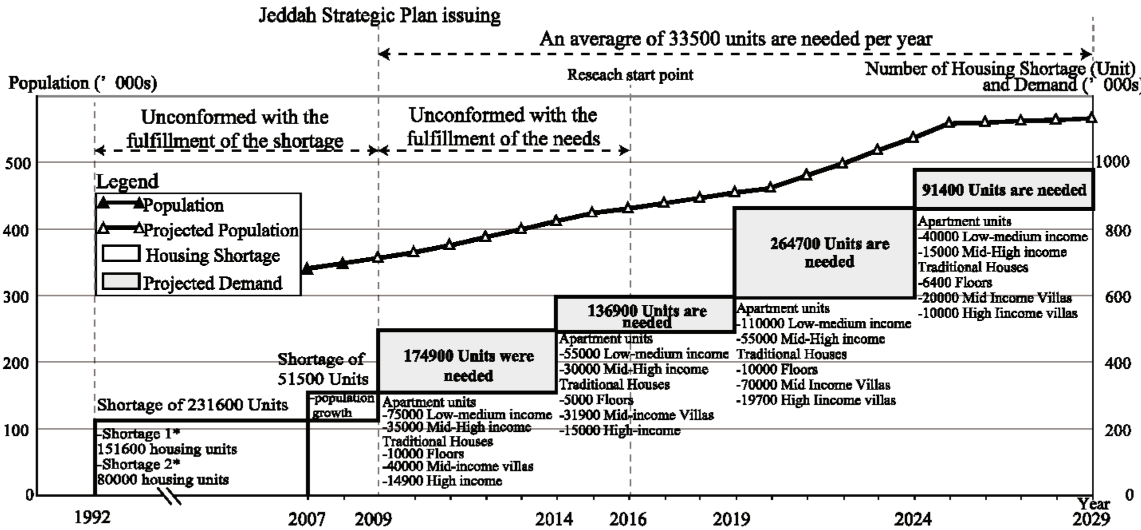

Figure 5. Population growth in Jeddah, the total housing shortage, and the projected housing demand up to 2029 (* Refers to shortages mentioned in Figure 6).

2.2. The Housing Shortage Problem and Related Factors

Jeddah's housing shortage is the outcome of a complex web of issues, encompassing the Jeddah without Slums Program (JWSP), in addition to problems relating to financing and economic hurdles, the master plan, the housing policy, and the legal framework, as depicted in Figure 6.

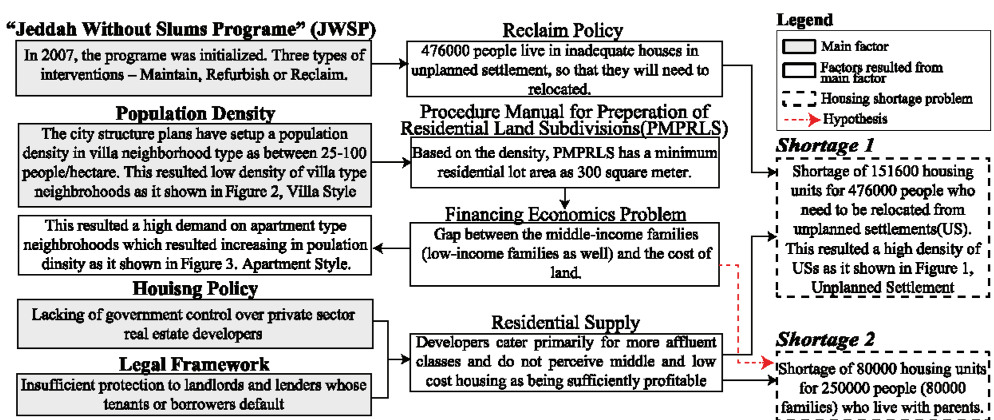

Figure 6. Housing shortage problem and related factors.

1. Jeddah without Slums Program (JWSP)

The JWSP program, which was established in 2007 by royal decree, is aimed at reclaiming unplanned settlements in the city. The results of a survey conducted by the Jeddah Municipality and released in 2007 indicated that there were three categories of buildings in unplanned settlements: those that need to be maintained, refurbished, or reclaimed. The Jeddah Municipality announced that 476,000 people (approximately 151,600 households) would need to be relocated from unplanned settlements because of dangerous housing conditions [9].

2. Population Density

Jeddah has grown during the implementation of five different master plans formulated during different periods by different planners, each of whom arrived at different population densities for the city's neighborhoods (Table 1).

3. Housing Policy

The government lacks control over private sector real estate developers, but, in addition, the developers cater primarily to the more affluent classes and do not perceive middle and low-cost housing projects as being sufficiently profitable.

4. Legal Framework

The shortage of housing is also linked to the legal framework, which provides insufficient protection to landlords and lenders whose tenants or borrowers default.

5. Financing Economics Problem

In 2008, the average cost of 100 m^2 of raw (undeveloped) land in Jeddah was 2.24 times higher than the average family income, and the cost of 100 m^2 of serviced land (land with electricity, roads, and water) was, on average, 19.4 times higher than the average family income [9]. This is one of the main factors accounting for the increased number of two-generation houses (approximately 80,000 households).

2.3. Population Density in Residential Districts

The low population density within Jeddah's structural plans (Table 1) has resulted in an average lot area of 500–1000 m^2 in villa-type neighborhoods. This is a limiting factor with regard to the increasing rate of villas in such neighborhoods compared with apartment-type neighborhoods, as shown in Figures 6 and 7, with households whose incomes are medium-low or low finding it difficult to buy and own villas.

Figure 7 shows the relationship between the change in population density (at four time points) and the percentage of park area from 2007 to 2012 for each district, in terms of the two housing types, Villa type and Apartment type, and Unplanned Settlement. It shows that park area has not increased while population density has increased for 5 years, which is in line with the WHO recommendation of park area per capita. This indicates that the living environment and quality of life is declining and that villa-type housing may also fall below the WHO standard in the future.

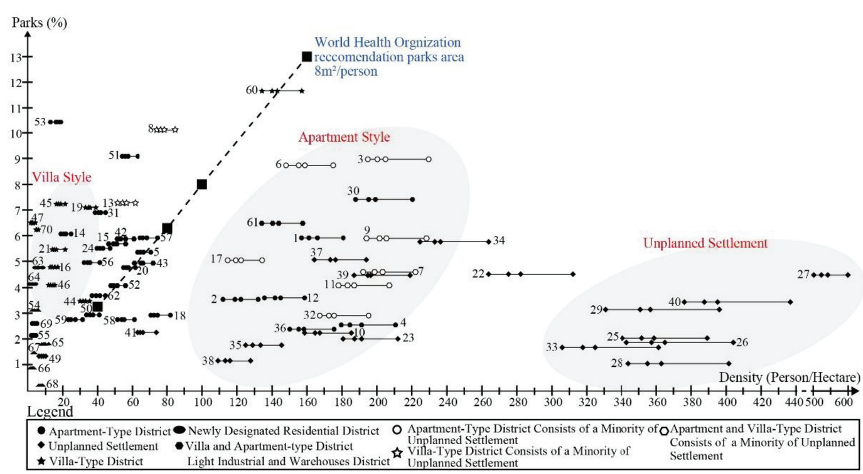

Figure 7. Population density and park ratio by districts in 2007, 2008, 2009, and 2012 in Jeddah.

3. New Villa-Type Neighborhood Development

3.1. Procedure Manual for Preparing of Residential Land Subdivision (PMPRLS)

During Jeddah's urbanization process, areas outside the boundaries of each urbanized area afforded attractive investment opportunities for businesses. Consequently, large areas of land have been bought and sold and then subdivided into residential lots to create neighborhoods in line with the PMPRLS.

The PMPRLS comprises several regulations on public spaces, such as streets, parks, mosques, and parking areas, and private spaces, such as residential lot areas, and their dimensions. Regulations relating to public spaces are as follows. First, land allotted for local mosques must have a service distance that does not exceed 200 m. Second, land for elementary and intermediate schools must be provided at a service distance that does not exceed 550 m (the ratio is not mentioned). Third, the total street must not exceed 20% of the total area. Fourth, the maximum total street length based on the average area of the villa lot is shown in Table 2. Fifth, one children's playground, having a minimum area of 400 m^2, should serve 20 villas. Finally, the total area of public facilities, such as parks, the parking areas of amenities, pedestrian corridors, and the central square, should be 13% of the total area.

Table 2. Average areas of lots and total street length in the New Development Plan for villa-type neighborhoods (according to the Procedure Manual for Preparing of Residential Land Subdivision).

Average Area of Villa Lot (in m^2)	Maximum Total Street Length (MTSL) within 1 ha of Land (m)	Maximum Total Street Length in an Area with a Radius of 200 m (Equivalent to 12.56 ha in Total Area)
300	130	1633
400	120	1507
600	110	1382
800	100	1256
1000	95	1193
2000	80	1005
2500	75	942

Private space-related regulations are as follows. First, the minimum land lot area for a villa is 300 m^2 or, if a lot is subdivided, 200 m^2, and the minimum width of a residential lot should be 15 m. As noted in the manual, an average household size of five persons is assumed for calculating the population and population density. Figure 8 shows the composition of the villa-type neighborhood as per the PMPRLS.

3.2. Application of the Procedure Manual in Relation to an Area with a Radius of 200 m

Table 3 shows the total street area, the number of villas, population density, and the number of children's playgrounds according to the percentage of the total street area (20% of the total area), the total area of public facilities (13% of total area), and the total street length. As noted above, according to the PMPRLS, this area has a radius of 200 m (12.56 ha) from the mosque at its center. By contrast, Table 4 shows the application of the PMPRLS to the above-mentioned land area, with a difference in the street width, i.e., a minimum street width of 10 m, which is mentioned in the PMPRLS.

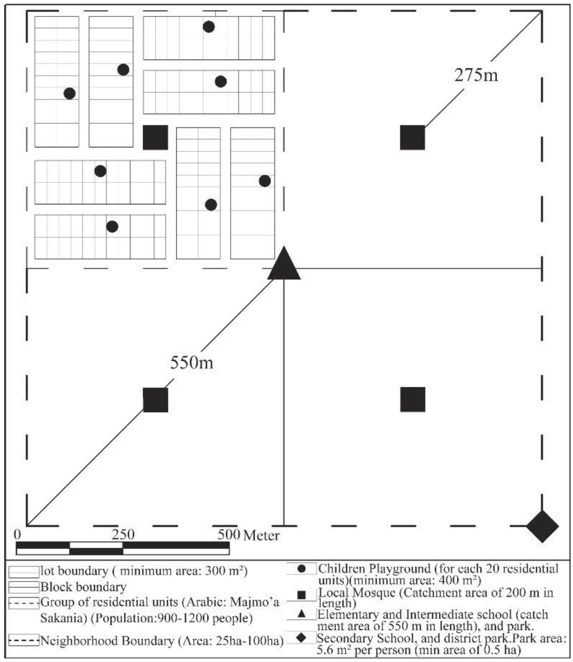

Figure 8. Conceptual depiction of a neighborhood based on the Procedure Manual for Preparing of Residential Land Subdivision.

Table 3. Applying the Procedure Manual for Preparing of Residential Land Subdivision to an area having a radius of 200 m (12.56 hectare in total area) with a maximum street capacity and variations in villa lot areas.

AoVLA (ha)	STA (ha)	PFTA (ha)	TSL (m)	NoV (Unit)	PD Person/ha	NoCP (Unit)
0.03 (300 m^2)	2.56 (20%)	1.63 (13%)	1633	279	111	14
0.04 (400 m^2)			1507	210	84	11
0.06 (600 m^2)			1382	140	56	7
0.08 (800 m^2)			1256	105	42	5
0.1 (1000 m^2)			1193	84	34	4
0.2 (2000 m^2)			1005	42	17	2
0.25 (2500 m^2)			942	34	13	2

Note: AoVLA: Average of Villa Lot Area (in hectares), STA: street total area (hectare) = 12.56 × 0.2, STA%: street total area (percentage) = STA × 100/12.56, PFTA: public facilities total area (hectare) = 12.56 × 0.13, TSL: total of street length (m) = MSTL (see Table 2) × 12.56, NoV: number of villas = 12.56 × (1 − STA (0.2) − PFTA (0.13))/AoVLA, PD: population density (persons/hectare) = NoV × 5/12.56, NoCP: number of children's playgrounds = NoV/20.

As shown in Table 3, the MoMaRAaH did not consider any direct correlations between the average villa lot and total street areas and the total area of public facilities, in spite of variations in the number of villas, population density, and the number of children's playgrounds. Accordingly, as shown in Table 4, the same number of public facilities will apply to an area with 111 persons/hectare as to an area with 13 persons/hectare, although there are variations in the average land areas occupied by villas and streets. The ratio of the total area of public facilities is fixed. This means that 16 persons/hectare (in our case study of 12.56 ha and a total of 192 persons) will receive the same quantity of public facilities as an area with 123 persons/hectare.

Table 4. Applying the PMPRLS to an area having a radius of 200 m (a total area of 12.56 ha) with streets of a minimum width of 10 m and varied villa lot areas.

AoVLA (ha)	STA (ha)	PFTA (ha)	TSL (m)	NoV (Unit)	PD (Person/ha)	NoCP (Unit)
0.03 (300 m^2)	1.63 (13%)	1.63 (13%)	1633	310	123	15
0.04 (400 m^2)	1.51 (12%		1507	236	94	12
0.06 (600 m^2)	1.38 (11%		1382	159	63	8
0.08 (800 m^2)	1.26 (10%)		1256	121	48	6
0.1(1000 m^2)	1.13 (9%)		1193	97	39	5
0.2(2000 m^2)	1.00 (8%)		1005	50	20	2
0.25(2500 m^2)	1.00 (8%)		942	40	16	2

Note: AoVLA: Average of Villa Lot Areas (in hectares), STA: street total area (hectare) = STA= TSL × 0.001 ha (= 10 m street minimum width)/12.56, PFTA: public facilities total area (in hectares) = 12.56 × 0.13, TSL: total of street length (m) = MSTL (Table 2) × 12.56, NoV: number of village s = 12.56 × (1 − STA(changeable) – PFTA (0.13))/AoVLA, PD: population density (people/hectare) = NoV × 5/12.56, NoCP: number of children's playgrounds = NoV/20.

4. Existing Conditions in Villa-Type Neighborhoods According to the PMPRLS

4.1. Index Analysis

The index analysis was developed using geographic information system (GIS) data obtained from the Jeddah Municipality, and the data were exported to an AutoCAD file. Areas within a 200 m radius (an area of approximately 12.56 ha) for mosques in villa-type neighborhoods (103 in total) were analyzed in Jeddah (Figure 4).

The index was subdivided into private and public spaces. Private spaces comprised elements such as villas, commercial facilities, and office buildings. Public spaces comprised facilities such as a mosque, an elementary school, a street, and parks. The following six parameters were established for analyzing villas: (1) numbers of villas in 2008 and 2016; (2) total areas of villas (average and median values and minimum and maximum values and the differences between them); (3) the minimum, maximum, and median values for the distances of existing villas' lot frontage and their proportion to the lot length; (4) the number of villas facing 1, 2, 3, and 4 streets; (5) the average land value in the SAR (per square meter); and (6) the total area for commercial facilities and office buildings. Nine parameters were selected to analyze public space: (1) the total area of streets; (2) the total road length; (3) the road width (maximum and minimum values, and the difference between them, and the median value); (4) the distance from a mosque to the nearest mosque; (5) the area of land occupied by the mosque; (6) the distance to the nearest elementary school; (7) the number of parks, and the distance to the nearest park and the park lot area; (8) the total area of the vacant lot; and (9) the total area of public facilities, and public parking.

4.2. The PMPRLS and Actual Condition

A scatterplot was created to analyze and clarify the following issues: (1) the extent to which the PMPRLS is applied, and (2) the typology of villa-type neighborhoods to clarify the extent to which the PMPRLS is applied. The correlation coefficients for several factors relating to the PMPRLS were calculated by performing regression analysis for existing conditions, the results of which are shown in Figures 9–12.

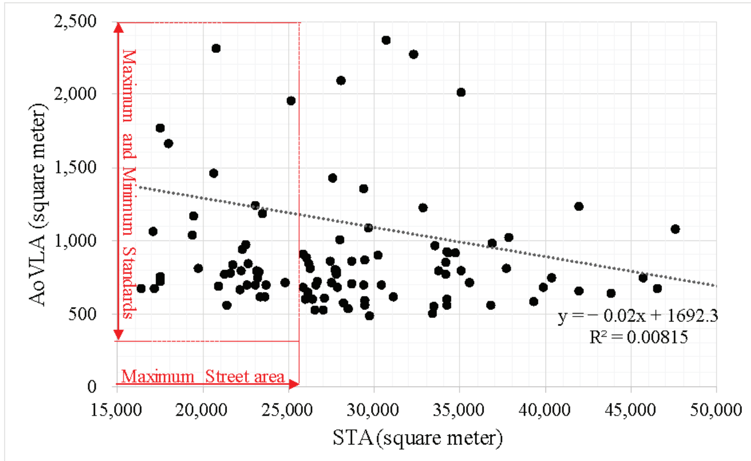

Figure 9. Street total area and average of land lot area.

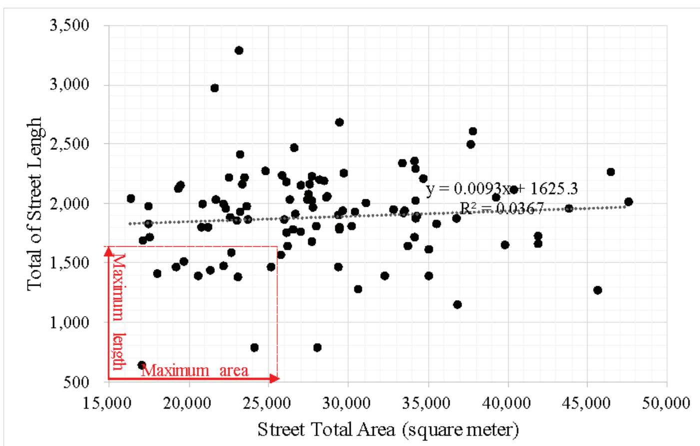

Figure 10. Street total area and total street length.

Figure 9 shows that only 32% of the study sites are within the standard street total area (STA), whereas 68% exceed the maximum standards. Moreover, 73% of the average of villa land lot area (AoVLA) is between 500 and 1000 m^2. Moreover, the correlation between the STA and AoVLA was weak for existing conditions, as shown by the value of *R*, which was 0.00815 (where a perfect correlation has a value of 1).

Figure 10 shows that only 11.5% of the study sites were within the STA and TSL (total street length) standards, with 88.5% of the sites exceeding the maximum standard. Furthermore, the TSL in 77.7% of the study sites was found to be between 1500 and 2500 m. As shown in Table 4, there was a perfect correlation between the AoVLA and the TSL. However, 94% of the study sites exceeded the standards curve (Figure 11).

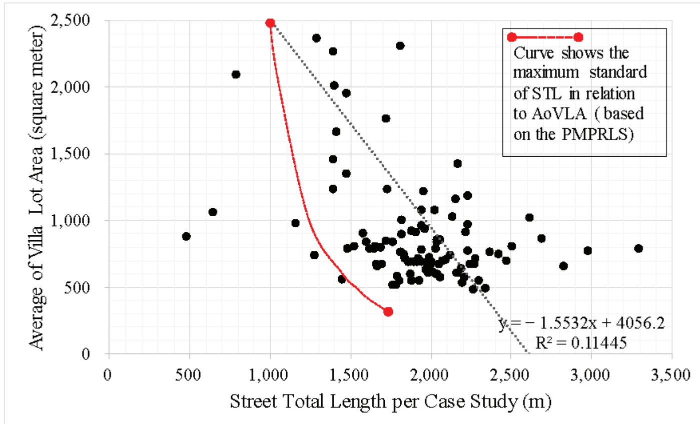

Figure 11. Total street length and average villa lot area.

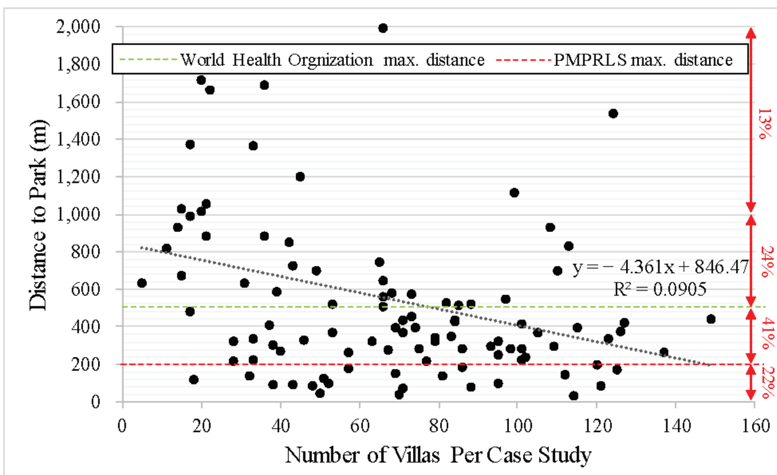

Figure 12. Number of villas and distance to park.

Figure 12 shows the final PMPRLS factor, which is the correlation between the number of villas and the distance to the nearest park. According to the PMPRLS, one children's playground must be provided for every 20 villas. However, our results indicated that the number of children's playgrounds (NoCP) was not applicable in reality (Table 3); therefore, we decided to investigate the distance to the nearest park instead. Two criteria were established: parks within a 200 m distance and those within a 500 m distance according to the distance recommended by the World Health Organization (WHO). In 24% of the sites, the distance to the park was between 500 and 1000 m. It was clarified that only 22% of study sites have a distance to the nearest park of 200 m which is based on the PMPRLS; however, only 41% of study sites met the recommendation of WHO regarding the distance to a park, which is 500 m. In addition, 24% of study sites are far away from parks, having a distance between 500 and 1000 m. Finally, 13% of study sites have a distance of more than 1000 m to the nearest park.

4.3. Contemporary Villa-Type Neighborhoods and the Housing Shortage

As shown in Figure 13, the number of villas in all of the study sites increased but at different rates. This finding indicates the need to examine the extent to which contemporary neighborhoods can respond to the problem of the housing shortage, which amounts to 80,000 units (Figure 6, Shortage 2). To examine this question, we assumed that the occupation pattern for the total vacant area in each site would match the growth pattern. The calculation was performed by determining the total vacant area (m^2) and the average lot area of already-built villas in each study site. The following formula was applied for each study, with the results shown in Table 5:

$$f(total\ number\ of\ villas) = \frac{TVA(total\ vacant\ area)}{AVLA\ (average\ of\ villa\ lot\ area)}$$

where f denotes the total number of villas that can be added to the total vacant area in the same tendency. *TVA* denotes the total vacant area (m^2), and *AVLA* denotes the average of villa lot area (m^2). f includes a decimal point in the number of villas because *AVLA* is a projection of future development. *TVA* is defined as the total area to be built on, excluding roads, within an area of 12.56 ha, which is based on a radius of 200 m centered on each mosque.

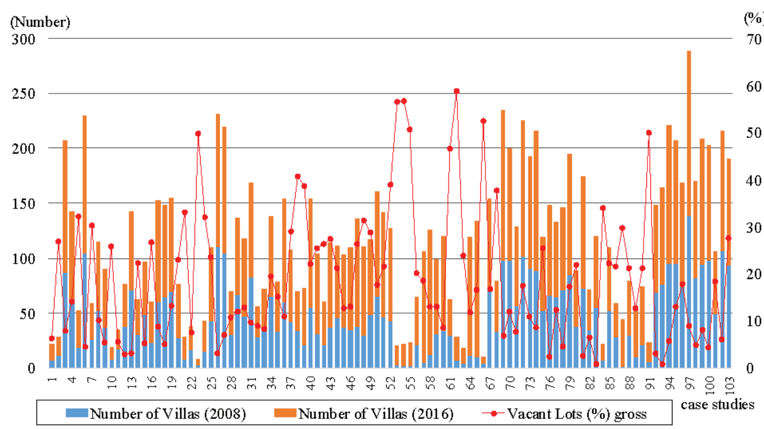

Figure 13. Numbers of villas in 2008 and 2016, and the ratio of vacant lots.

Table 5. Number of villas that can be added to a vacant lot area in each case study in a scenario entailing the same growth pattern.

CSN	f	CSN	f	CSN	f	CSN	f	CSN	f
1	3.7	22	4.0	43	49.7	64	23.8	85	24.0
2	16.8	23	3.1	44	39.4	65	36.1	86	21.9
3	17.5	24	28.1	45	20.0	66	29.0	87	55.0
4	23.5	25	29.4	46	22.9	67	36.4	88	31.4
5	24.3	26	5.9	47	49.0	68	56.1	89	19.7
6	10.3	27	12.8	48	56.7	69	13.8	90	24.6
7	51.0	28	19.8	49	48.3	70	22.0	91	79.3
8	15.2	29	22.4	50	31.6	71	15.1	92	6.7
9	6.8	30	20.9	51	45.1	72	35.8	93	1.6

Table 5. *Cont.*

CSN	*f*	CSN	*f*	CSN	*f*	CSN	*f*	CSN	*f*
10	7.1	31	17.3	52	87.3	73	19.2	94	14.8
11	3.0	32	10.4	53	48.8	74	15.2	95	27.2
12	2.0	33	8.7	54	67.0	75	39.9	96	40.6
13	4.4	34	34.2	55	51.5	76	3.6	97	22.2
14	27.3	35	15.4	56	42.8	77	16.9	98	9.1
15	7.1	36	15.8	57	38.6	78	6.3	99	14.7
16	36.3	37	37.8	58	31.4	79	27.8	100	7.5
17	13.9	38	54.4	59	20.2	80	32.1	101	29.2
18	7.7	39	79.2	60	15.4	81	2.9	102	9.8
19	19.5	40	41.8	61	112.6	82	10.4	103	49.8
20	29.5	41	44.2	62	54.7	83	1.0	-	-
21	21.2	42	36.6	63	40.3	84	47.0		
Total number of villas that can be added to the total vacant area in all of the sites in a scenario entailing the same growth pattern								2843 units	

CSN = the case study number, and *f* = the total number of villas that can be added to the total vacant area in a scenario entailing the same growth pattern.

The results of the calculations shown in Table 5 clearly indicate that, within contemporary villa-type neighborhoods, the pattern of full occupation by villas is the same for each case study, with neighborhoods only meeting 3.5% of the total housing shortage (2843 units/80,000 units $\times$ 100). Given this finding, in addition to several differences between the case studies relating to aspects such as land price, average lot area, the net of the total vacant lot, and others, it was necessary to clarify the indicators (mentioned above in the index analysis) that demonstrated a strong correlation via correlation analysis. The indicators were then categorized into groups according to the results of the multiple linear regression analysis and scatter plot, as discussed in the following section.

5. Elements of Neighborhoods and Their Correlations

5.1. Correlation Analysis

To contribute to addressing the housing shortage problem, it is necessary to predict the growth possibilities of villa-type neighborhoods starting from the present. This prediction was performed by analyzing the characteristics and composition of contemporary villa-type neighborhoods. In order to understand the correlation between housing development trends, and the site and surrounding facilities over an 8-year period, several factors, such as the number of development sites, site area and proportion of lots, and distance between mosques and highways in 2008 and 2016, along with land prices, a factor also considered to be important in previous studies, were adopted to perform correlation analysis.

The results obtained for the increase in the number of villas within the 8-year period revealed a negative correlation of -0.447 between the land price and the increased number of villas. This result indicates that there was a higher increase ratio for the number of villas in sites where land prices were lower. However, the correlation for lots that ranged in area between 300 and 400 m^2 was stronger, with a positive correlation of 0.548. Thus, there was a higher possibility of growth for small villa lots that was strongly related to the possibility of purchasing these lots. In addition, the proportion of the lot's frontage and depth was more than 2:1 for lots with areas within a range from 300 to 400 m^2, with a positive correlation of 0.468 (Table 6).

Table 6. Correlation analysis among the several factors during an 8-year period.

		Increase in the Number of Villas between 2008 and 2016	Average Land Price	Ratio of Lots within a 300–400 m^2 Range	Ratio of Lots within a 500–600 m^2 Range	Proportion of Lots with a Frontage and Depth Ratio over 2:1	Ratio of Lots Facing One Road	Distance between Mosque and Highway (m)	Total Area of Roads (m^2)	Number of Lots in 2008	Number of Lots in 2016
Increase in the number of villas 2008–2016	Pearson Correlation	1									
	Sig. (2-tailed)										
Average land price	Pearson Correlation	−0.447 **	1								
	Sig. (2-tailed)	0.000									
Ratio of lots with areas ranging between 300 and 400 m^2	Pearson Correlation	0.548 **	−0.252 *	1							
	Sig. (2-tailed)	0.000	0.010								
Ratio of lots with areas ranging between 500 and 600 m^2	Pearson Correlation	0.009	−0.072	−0.049	1						
	Sig. (2-tailed)	0.463	0.471	0.620							
Proportion of lots with a frontage and depth ratio greater than 2:1	Pearson Correlation	0.404 **	−0.161	0.468 **	−0.219 *	1					
	Sig. (2-tailed)	0.000	0.104	0.000	0.026						
Ratio of lots that facing one road	Pearson Correlation	0.428 **	−0.389 **	0.350 **	0.244 *	0.112	1				
	Sig. (2-tailed)	0.000	0.000	0.000	0.013	0.258					
Distance between mosque and highway	Pearson Correlation	0.480 **	−0.501 **	0.279 **	0.058	0.154	0.265 **	1			
	Sig. (2-tailed)	0.000	0.000	0.004	0.562	0.121	0.007				
Total area of roads	Pearson Correlation	−0.147	0.481 **	0.140	0.135	−0.075	0.030	−0.293 **	1		
	Sig. (2-tailed)	0.069	0.000	0.159	0.173	0.451	0.762	0.003			
Number of lots in 2008	Pearson Correlation	−0.188 *	0.052	−0.053	0.495 **	−0.360 **	0.285 **	−0.160	0.063	1	
	Sig. (2-tailed)	0.028	0.599	0.596	0.000	0.000	0.003	0.106	0.528		
Number of lots in 2016	Pearson Correlation	0.441 **	−0.226 *	0.288 **	0.458 **	−0.081	0.523 **	0.148	−0.033	0.798 **	1
	Sig. (2-tailed)	0.000	0.022	0.003	0.000	0.414	0.000	0.136	0.743	0.000	

Note. N = 103. ** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed). The shaded cells have a high correlation between two factors, which is mentioned in-depth in Section 5.1.

Furthermore, over the 8-year study period, the number of villas was positively correlated (0.480) with the distance between the mosque and the highway. However, there was a negative correlation (−0.501) for the distance between the mosque and the highway and the average land price, which means that the distance between the highway, and the mosque had the effect of increasing the land price, with greater proximity to the highway corresponding to a higher land price. In addition, there was a positive correlation (0.481) between the average land price and the road area. However, among the sites evidencing growth within the 8-year study period, those with limited street areas and low prices showed a significant increase in the number of villas.

In addition, the results of the analysis showed a positive correlation (0.458) between the increased number of villas in 2016 and the ratio of lots ranging in area between 500 and 600 m^2. However, this correlation was lower than the value obtained in 2008 (by 0.037) of 0.495. Furthermore, the analysis revealed a striking relationship between lots that faced one road and the number of villas that increased between 2008 and 2016, indicated by a positive correlation of 0.523. As noted above, between 2008 and 2016, the majority of the new villas were constructed with lots ranging between 300 and 400 m^2, and a decreased correlation value was found for lots having areas between 500 and 600 m^2. Therefore, it is clear that most of the contemporary lots ranging in size between 500 and 600 m^2 were built before 2008.

5.2. Multiple Regression Analysis

To develop a formula for predicting villa development, we conducted a multiple regression analysis with the changing rate of increase in the number of villas over 8 years as the object variable, and 26 criteria as explanatory variables (Table 7). We devised the regression formula through repeated parallel implementation of a stepwise selection method and a forward selection method.

Table 7. Related criteria for the multiple regression analysis.

Villa Growth-Related Factor	1. Increase in the Number of Villas between 2008 and 2016			
Ratio of lot-related factors	1. under 300 m^2 5. 600–700 m^2 9. 1400–1800 m^2	2. 300–400 m^2 6. 700–800 m^2 10. 1800–2200 m^2	3. 400–500 m^2 7. 800–1000 m^2 11. 2200–3000 m^2	4. 500–600 m^2 8. 1000–1400 m^2 12. over 3000 m^2
Proportion of lot's frontage and depth related factors	1. under 1	2. 1–1.5	3. 1.5–2	4. over 2
Land price-related factor	1. Average land price			
Vacant lot-related factor	1. Total area of villa lots		2. Ratio of vacant lot (net)	
Park-related factors	1. Number of parks	2. Distance between mosque and park		3. Total area of parks
Mosque-related factors	1. Distance between mosques		2. Distance between mosque and highway	
Road-related factors	1. Total area of roads	2. Total length of roads		
Total	27 criteria			

The following formula was used to predict villa development according to the increase in the number of villas over 8 years:

$$\text{Increase in the number of villas over 8 years} = 27.724 - 0.02 \times (\text{Land price}) + 1.296 \times (\text{ratio of lots with areas ranging between 300 and 400 m}^2)$$

The coefficients were significant at the 0.01 level, and the Variance Inflation Factors (VIFs) among two criteria (the land price and ratio of lots with area ranging between 300 and 400 m^2) all had values under 1.068, and thus satisfied the requirement of being under 10. The Durbin–Watson test yielded a value of 1.750, indicating the independence of the criteria (Table 8). The adjusted *R*-squared value was 0.391, which explained 39.1% of the number of increased villas over 8 years (Table 8). The standardized coefficients of these two criteria were respectively −0.330 and 0.465, so that the ratio of lots with areas ranging between 300 and 400 m^2 was evidently of greater significance than the land price (Table 9). These results indicate that, over the 8-year study period, villa development occurred mainly in lower-priced villa lots having areas ranging between 300 and 400 m^2. Thus, the optimal area of the lot for villa development considering purchasing ability is between 300 and 400 m^2.

Table 8. Summary of model for predicting the increase in the number of villas as an explanatory variable.

R	*R*-Square	Adjusted *R*-Square	Change Statistics					Durbin–Watson
			R-Square Change	F Change	df1	df2	Sig. F Change	
0.634	0.403	0.391	0.403	33.688	2	100	0.000	1.750

Note, Predictors: (constant), land price, ratio of lots having areas that range between 300 and 400 m^2.

Table 9. Coefficients for the change rate of the number of villas as an explanatory variable.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	27.724	3.961	-	6.999	0.000	-	-
	Land price	−0.002	0.001	−0.330	−4.132	0.000	0.937	1.068
	Ratio of lots ranges between 300 and 400 m^2	1.298	0.223	0.465	5.823	0.000	0.937	1.068

The following formula was used to predict the net ratio of vacant lots:

Net ratio of vacant lots = 53.368 + 0.011 × (distance between mosque and park) − 0.015 × (total length of roads) + 0.517 × (ratio of lots with areas ranging between 1000 and 1400 m^2)

The coefficients were significant at the 0.01 level, and the VIFs for the three criteria (the distance between a mosque and a park, the total length of roads, and the ratio of lots having areas ranging between 1000 and 1400 m^2) were all under 1.154, and thus satisfied the requirement of being under 10. The value obtained for the Durbin–Watson test was 1.821, indicating the independence of the criteria (Table 10). The adjusted *R*-squared value was 0.281. The standardized coefficient values for these three criteria were respectively 0.243, −0.288, and 0.269, revealing that the three criteria were almost equally significant. To reduce the ratio of vacant lots using the above predictive formula would require developing parks near mosques and not increasing the total length of roads. Moreover, the areas of villa lots ranging between 1000 and 1400 m^2 would need to be reduced (Table 11).

Table 10. Summary of the model used to calculate the net ratio of vacant lots.

R	*R*-Square	Adjusted *R*-Square	Change Statistics					Durbin–Watson
			R-Square Change	F Change	df1	df2	Sig. F Change	
0.549	0.302	0.281	0.065	9.252	1	99	0.003	1.821

Predictors: (constant), distance between mosques and parks, total length of roads, and ratio of lots that range in area between 1000 and 1400 m^2.

Table 11. Coefficients for the net ratio of vacant lots as an explanatory variable.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	53.368	9.359	-	5.703	0.000	-	-
	Distance between mosque and park	0.011	0.004	0.243	2.689	0.008	0.867	1.154
	Total length of roads	−0.015	0.004	−0.288	−3.346	0.001	0.951	1.052
	Ratio of lots ranges between 1000 and 1400 m^2	0.517	0.170	0.269	3.042	0.003	0.901	1.110

5.3. Groupings and Suggestions

We applied Ward's method to perform cluster analysis using the standardized scores for six criteria associated with villa development and the net ratio of vacant lots, the ratio of villa lots having areas ranging between 300 and 400 m^2, the ratio of villa lots having areas ranging between 1000 and 1400 m^2, the average land price, the total area of vacant lots, the distance between a mosque and a park, and the total road length (Figures 14–16). The 103 target areas were categorized into six groups (Figure 17). The characteristics and recommendations for reducing the net ratio of vacant lots are presented below.

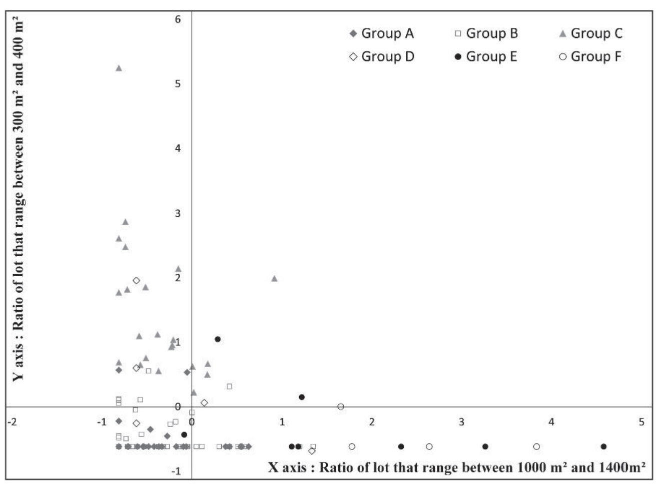

Figure 14. Scatter diagram (1).

1. Group A (26 sites)

The neighborhoods included in this group evidence the following characteristics: (1) the areas of a few lots range between 300 and 400 m^2; (2) the total area of vacant lots is relatively large; (3) land prices are high; and (4) the road lengths are short compared with those of other groups. Because of the relatively large total area of vacant lots, it is necessary to delineate existing lots with areas ranging between 300 and 400 m^2 along with increasing road length for improving the street environment and reducing the ratio of vacant lots. In addition, increasing the number of parks to respond to the increase in population density is recommended, thereby increasing the possibility of consumers being able to purchase lots.

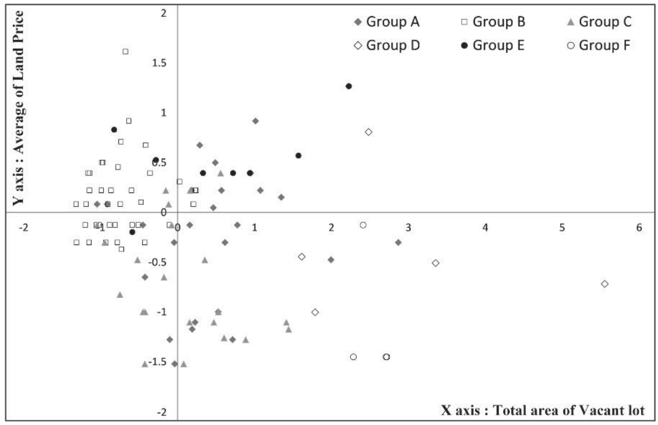

Figure 15. Scatter diagram (2).

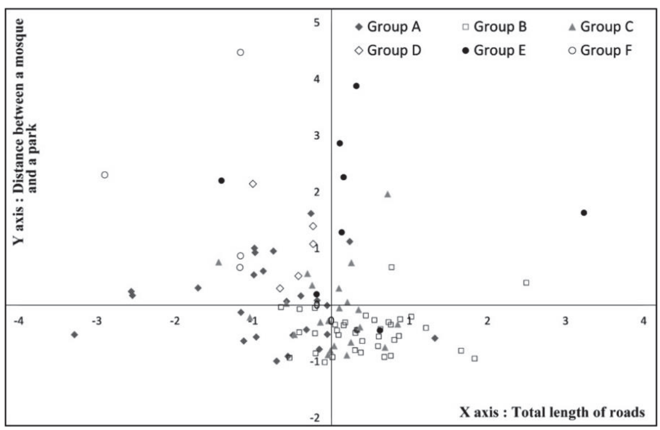

Figure 16. Scatter diagram (3).

2. Group B (38 sites)

The neighborhoods included in this group share the following characteristics: (1) a certain number of villas have been built in lots with areas ranging between 300 and 400 m^2; (2) a few vacant areas are present; (3) the total street length is substantial; and (4) there is a short distance between the mosque and park. As the majority of lots within this group have already been developed, there are no further recommendations or changes needed.

3. Group C (22 sites)

This group is distinguished by the following characteristics: (1) a large number of lots that range in area between 300 and 400 m^2; (2) relatively low average land prices compared with those of other groups; (3) a substantial total street length; and (4) a short distance between mosques and parks. These characteristics indicate that there has been active construction of villas over the last 8 years. Moreover, a clear projection of an increase in villas within lots that range between 300 and 400 m^2 in the area can be made for several years into the future.

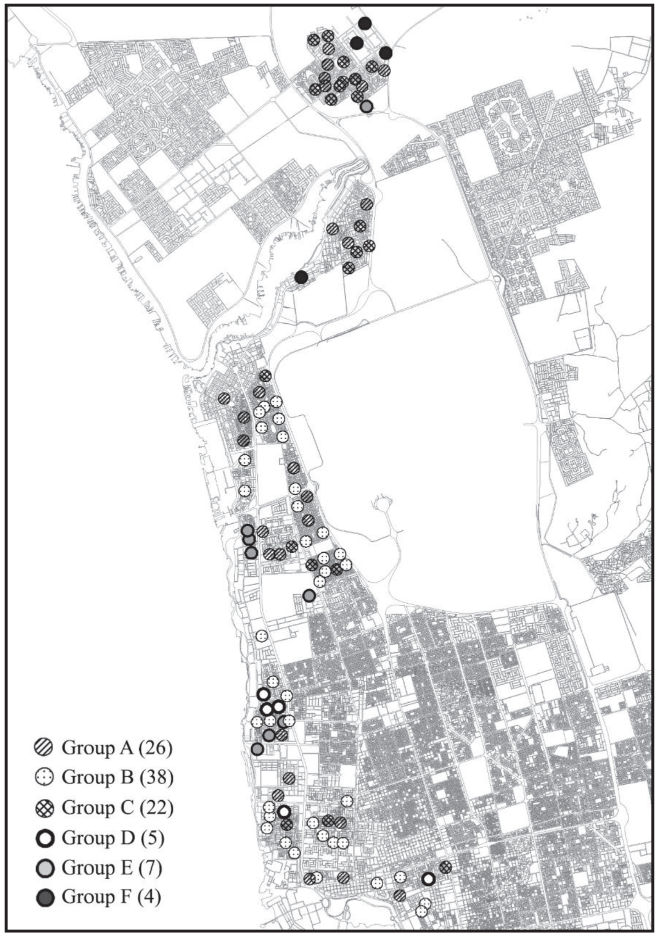

Figure 17. Locations of the study sites and their groupings.

4. Group D (5 sites)

This group is characterized by: (1) a few villa lots ranging in area between 300 and 400 m^2, and also between 1000 and 1400 m^2; (2) a large total area of vacant lots in spite of a low average land price; and (3) a significant distance between a mosque and a park relative to other groups. Our analysis of the locations of the study sites clearly revealed that the locations of lots categorized in this group were not attractive residential sites because of their geographical characteristics. Thus, it is necessary to divide the lots into small-sized lots and to improve the environment by creating parks in these neighborhoods.

5. Group E (7 sites)

A large number of villa lots ranged in the area between 1000 and 1400 m^2. Not only are average land prices high for lots in this group, but there is a considerable distance between mosques and parks. Our analysis revealed a strong trend toward increased villa construction in large-sized lots. Thus, we recommend the development of a method for matching purchase ability through the division of existing villa lots with high land prices and the establishment of parks near the mosques.

6. Group F (4 sites)

Although the ratio of villa lots having areas ranging between 1000 and 1400 m^2 is high, the average land price is low. Nevertheless, vacant lots are evident. However, the total length of roads is very short, and parks are located very far from mosques. Evidently, some of these areas are unsuitable as residential environments. Therefore, special district planning is necessary for this type of neighborhood to increase the length of the roads and reduce the areas of villa lots.

6. Conclusions

Between 2007 and 2029, the estimated population growth of Jeddah, which is one of the most traditional and rapidly growing cities in Saudi Arabia, is expected to be around 2.25 million people. Faced with a serious housing shortage, the government proposed the provision of adequate new houses in response to the projected housing demand. Furthermore, within the SAR, villa-type housing is a historical and prestigious housing type compared with apartment-type housing. However, the proportion of villas is lower in Jeddah compared with these proportions in other cities. According to the PMPRLS, the characteristics of villa-type housing are a low population density and a minimum land lot area of 300 m^2. In this situation, we aimed to clarify the characteristics of 103 sites according to the development trend by applying several indicators derived from the articles of the PMPRLS. In light of our analysis and typology, we proposed desirable developmental directions for each type of site.

In Section 2 of this paper, we discussed the extent of and reasons for the housing shortage in the city and projected future needs in relation to population growth. Moreover, we described the population density in relation to the presence of parks in all of the districts in Jeddah. The low population density associated with villa size is an outcome of Jeddah's ongoing structural planning, and it is clear that middle- and low-income individuals will find it difficult to own villa-type housing. Assaf [25] noted that inadequate labor, availability, material standards, design quality, and design changes have affected affordable housing costs, and that development policies that can improve these conditions are needed to address the housing shortage problem in Saudi Arabia. In addition, this study also noted that urban development in Jeddah, which is sprawling at low densities due to residents' preference for villa-type housing, does not solve the housing shortage problem, and that the housing costs associated with ensuring the necessary villa size do not lead to housing affordability for middle- and low-income individuals.

In Section 3, we discussed legislation for new residential area development with the PMPRLS, showing how contemporary neighborhoods were created. We also simulated population density, total street area and length, and numbers of parks and villas in relation to this legislation. Evidently, the MoMaRAaH did not consider the direct correlation between the average villa lot area and the total areas of streets and public facilities. The ratio of the total area of public facilities is fixed, even though there are variations in population density related to villa size. As highlighted by Hegazy (2021), there is a lack of planning tools for managing the urban planning system in Jeddah; thus, it is necessary to review the PPMPRLS of Jeddah to consider more diversity in lot areas, population density, street ratio, and park layout. This diversity is an important element of the solution to the housing shortage problem.

In Section 4, we analyzed the extent to which the legislation on new development of residential areas is applied in contemporary neighborhoods. In addition, we clarified the extent to which neighborhoods can respond to the housing shortage problem in terms of the quantity of housing provided. Based on the trend, which was calculated by the number of villas added to the total vacant area in the same development pattern and lot size, only 3.5% of the total shortage of housing problem would be solved. Alqahtany [26], based on the Saudi vision 2030 plan, discussed the problem of shortage of affordable housing in terms of housing cost, population change, etc. It is necessary to develop a solid strategy for the next 10 years to deal with the serious housing shortage problem projected in Jeddah.

A correlation analysis and multiple regression analysis were also presented to identify several factors that were correlated with each other. The results of the multiple regression analysis showed that the increase in the number of villas was related to the ratio of lots with areas ranging between 300 and 400 m^2 and the average land price; this means that an optimal size of villa lots for villa development and for reducing land prices is between 300 and 400 m^2. Our findings also revealed that the ratio of vacant lots is related to the distance between mosques and parks, the total road length, and the ratio of lots sized between 1000 and 1400 m^2. Therefore, future planning should accommodate the construction of parks near mosques and the extension of road length, as opposed to the total area of roads, and also reduce the sizes of villa lots within a range of 1000 and 1400 m^2. Finally, all of the contemporary villa-type neighborhoods were categorized into six groups and suggestions were provided for each group with the aim of addressing an aspect of the housing shortage problem using six criteria derived from the multiple regression analysis.

In the PMPRLS, the area of roads, public facilities, etc., is fixed and does not flexibly respond to changes in population density. As a result, the PMPRLS has not been able to introduce flexible lot sizes. The development trend shows that, as housing prices are expected to increase, the current custom of preferring large lot sizes will not solve the housing shortage problem, because middle- and low-income buyers will not be able to afford to purchase houses. It is important to ensure the diversity of housing supply, such as by dividing large lots into smaller ones.

To conclude, we analyzed neighborhoods in Jeddah from economic and policy perspectives, and proposed different recommendations for each group. However, the contents of the recommendations were limited to the total area and length of streets, the minimum area of villa lots, and land prices. Although we proposed improvement measures for each group, we did not simulate the actual quantitative numbers to determine the size of the increase in the number of housing units. Therefore, quantitative support to determine the extent to which the housing shortage can be improved is a subject for future study. Future research also should consider other important factors, such as pedestrianization and its relation to motorization within planned neighborhoods.

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