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Rural Space Modeling

Edited by
Krystyna Kurowska and Cezary Kowalczyk

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Editors

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About the Editors

Krystyna Kurowska

Interests: rural areas; sustainability; spatial planning; land use change; land use modeling; environmental analysis; urbanization

Main research objective: to formulate principles for using spatial data and spatial analyses in the promotion of sustainable development in rural areas.

My research interests also focus on the protection of agricultural land and forests, land management as an instrument for environmental protection, the absorption of EU funds and their influence on rural development, the management of real estate owned by the State Treasury, and the promotion of local development based on environmentally friendly investment projects. I use GIS tools to identify various spatial phenomena and propose rational land management practices.

Cezary Kowalczyk

Interests: urban analysis; land use/cover change; land use modeling; statistical approaches; real estate market.

The main objective of my research is to develop methodology for the analysis of spatial changes taking place in urban areas and the rules of their visualization. My other scientific interests include the following issues: the valuation and protection of agricultural and forest land, the improvement of tasks within real estate management, and making real estate available for the needs of infrastructure location. In my research, which covered the abovementioned topics, GIS tools were used to identify spatial phenomena.

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Editorial

Rural Space Modeling—Contemporary Challenges

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Rural areas feature mainly agricultural land and forests, and they are often referred to as non-urbanized areas whose spatial uniqueness can be credited to the planners' imagination, environmental and esthetic sensitivity, and environmental awareness.

As Kurowska et al. [1] emphasise in their study, there is currently no generally accepted definition of "rural areas" [2–4], and there is no consensus on how to construct a consistent definition [5,6]. The division of space into rural and urban space is a customary process that relies on various criteria in different countries. In Poland, these criteria are largely administrative, and space is generally considered rural until a given location receives town status pursuant to a regulation of the Council of Ministers. In some European countries, the legal designation of a town or city is based on population density. The urbanization threshold is 100 inhabitants per km^2 in the EU and 150 inhabitants per km^2, according to the criteria of the Organization for Economic Cooperation and Development (OECD).

Rural space combines four types of space:

Natural space, which is made up of ecosystem components that offer supportive conditions for the survival of biological species and have ecological value;

Social space, which is occupied by human communities that strive to satisfy their needs and contribute to the social value of space;

Cultural space, which features permanent objects of material cultural heritage that contribute to the cultural value of space;

Economic space, where humans conduct economic activity and contribute to the economic usefulness, relevance, and value of space.

Rural space has a conventional structure (it is composed of regions, linear features, and points) and is characterized by:

Limitedness—space cannot be enlarged;

Resistance—space is resistant to change;

Variation—space is diverse and heterogeneous.

Rural areas occupy a significant portion of geographic space in all countries, and they play a very important role in human lives. Rural areas are places of residence or work; they are tourist destinations where people spend their free time, relax, and come into contact with nature; but above all, they are a source of products and raw materials. Rural areas are often converted to other uses, most notably for the purpose of urban development. For this reason, rural areas should be managed rationally in line with sustainable development principles. All inhabitants can influence the ways in which the urban environment is managed and maintained. Geographic space is transformed to meet human needs, but ecological and economic concerns should not be overlooked in this process. Effective management should aim to instill spatial order because humans have an intrinsic need to organize the physical space in which they live [7,8]. Advanced technologies (such as multiple-criteria decision-making methods and GIS tools) are increasingly deployed in spatial analyses around the world [1]. This Special Issue focuses on the practical and theoretical applications of modern technologies in modeling rural space and planning rural development. According to Chen et al. [9], practical village planning is also an important support for building a sustainable rural development model.

In principle, all citizens participate in the management of space, although their involvement can take on different forms. Some individuals actively participate in this process by contributing to the development of a legal and economic framework for land management; some transform geographic space by relying on modern technologies and administrative tools, whereas others use space within the existing legal limits. As evidenced by Kopáček [10], civic participation has an irreplaceable role in the land-use planning process because it contributes a practical perspective to expert knowledge.

Rural areas continue to attract considerable research attention around the world. The topic of this Special Issue was selected based on a bibliographic analysis of articles published in WoS-indexed journals with the use of selected keywords. Articles containing the words "rural area" were selected from the database of papers published between 2017 and 2021. The search produced 25,000 records. The next stage of the analysis involved the VOSviewer software tool that can be used to construct and visualize co-occurrence networks of important terms extracted from a body of scientific literature.

The results of the analysis are presented in Figure 1 (only the links between the words that were identified at least 60 times as the keywords related to the term "rural area" are shown). The size of the node containing a given keyword denotes the frequency of its occurrence in published articles. An analysis of the results revealed that the searched term occurred primarily in two fields of research: socio-economic (in green) and spatial (red).

The main keywords in research papers dedicated to socio-economic development were: patient, child, age, participant, and woman. The results of these research studies were presented in both the temporal (year, month) and the quantitative (total, prevalence) approach.

When typical editorial terms were disregarded (paper, article, research, approach, issue, context, case study), the predominant keywords in the articles focusing on the spatial development of rural areas were: development, system, environmental value, municipality, city, village, and policy.

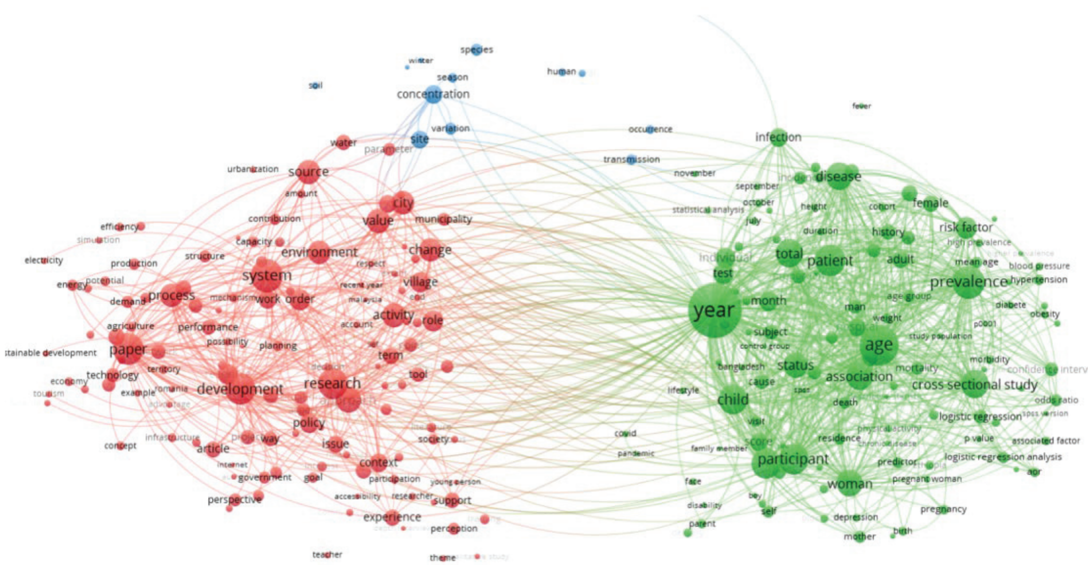

Figure 1. Visualization of the co-occurrence networks of the keywords in scientific publications containing the term "rural area".

The analysis confirmed that changes in geographic space have various causes and origins. Changes resulting from intentional actions are generally referred to as land management, whereas changes that occur as side-effects of intentional actions are mostly destructive in nature. In the spatial planning process, which is a land management tool, the term "spatial development" is often defined as a process of directed change that transforms geographic space from simpler and less effective systems to more complex and more optimal systems [11]. This definition of development is correct from the economic point of view, but it may not be appropriate in the environmental approach to land management. Sustainable development, a concept that combines various approaches to development, is the preferred mode of development. Sustainable development aims to balance all functions, including economic, social, ecological, cultural and spatial. This innovative concept represents the highest and the most desirable form of development in both science and practice.

Rural land management is one of the goals of spatial planning, and rural areas should be transformed in a sustainable manner. The ongoing debate on changes in rural areas raises the following questions:

What is the future of rural space?

Is the rural–urban divide a valid concept in the contemporary world?

What tools should be applied to develop an optimal model of rural space?

What is the role of spatial planning in the process of transforming rural areas?

Rural areas are often regarded as peripheral areas. However, rural areas can be highly attractive living and working environments on account of their unique natural and scenic attributes, including picturesque landscapes, presence of water bodies, forests and areas of high natural value. In recent years, rural areas in the European Union (EU) have been considerably transformed through Common Agricultural Policy (CAP) mechanisms. European funds promote agricultural restructuring, farm modernization and multifunctional rural development.

This Special Issue is dedicated to rural space modeling. It contains articles that evaluate the existing status of rural space and describe the necessary conditions for rural development. The presented papers emphasize the importance of rural space modeling in rural development. The demand for land that can be converted to non-agricultural uses is very high in rural areas, in particular those situated in the direct vicinity of urban agglomerations. The main aim of spatial planning is to eliminate or alleviate spatial conflicts at the rural–urban interface. All countries have implemented laws and regulations that promote rational planning and land management. Planning documents and decisions can impose limitations on land management and land-use type, but the absence of these regulatory instruments considerably hampers development. Zoning decisions (in Poland, zoning decisions define the permitted type of development and land use) are only temporary solutions that lead to monofunctional development of rural areas, residential fragmentation and undermine harmonious spatial development. Residential estates comprising single-family homes and apartment buildings are increasingly often developed in suburban areas [12]. As a result, small towns in the proximity of large cities are absorbed into the metropolitan area [13–15].

The main research objective conducted by Kurowska et al. [1] was to evaluate the applicability of geographic information system (GIS) tools (data, tools, and multidimensional analyses) to the implementation of sustainable development principles in rural areas. The study covered rural and nonurbanized areas in Poland, especially farmland, forests [16,17], fisheries [18], and farms [19]. GIS systems allow us to formulate, in a structured and formal way, models that reflect both the current state and forecast changes that will occur in space.

A different approach was used by Jukneliene˙ et al. [20]. The authors proved that he spatially explicit assessment of land use and land-use change patterns can identify critical areas and provide insights to improve land management policies and associated decisions. Mozgeris and Jukneliene˙'s [21] study focused on modelling future land use development on the example of Lithuania. The next article (Stręk et al.) dealt with land fragmentation and the distribution of plots in rural areas. The authors attempted to develop a universal land exchange algorithm for eliminating the external plot patchwork [22].

Chen et al. [9] conducted a case study on 38 villages to develop a practical village planning strategy for different types of villages. The aim of the study conducted by

Kopáček [10] was to assess whether there is an optimal level of civic participation in the land-use planning process. A secondary aim of this research was to suggest suitable ways of facilitating an optimal degree of participation in the land-use planning process. Finally, Kaminska and Mularczyk [8] determined the attractiveness of central public spaces in small Polish towns based on a spatial order analysis.

The presented articles also evaluate the impact of EU funds on regional changes in agricultural development and management of green areas. Jurjević et al. [23], using the example of Serbia, discussed a regional spatial approach to differences in rural economic development. Rudnicki et al. [24] were attempted to synthesise the diversity of CAP financial support using spatial typology methods. The researched support measures were divided into three basic directions for developing agriculture: ecology, environment and habitat. The study was conducted on the example of Poland, and the basic territorial unit of analysis was the commune. It was shown that support for environmentally friendly activities in Poland related to almost 10% of the total farm area.

Kupren and Hakuć-Błażowska [25] have demonstrated that hunting is an important part of socio-economic activities, particularly in rural areas. It is estimated that in the EU alone, hunting can be worth approximately EUR 16 billion, and creates 100–120 thousand jobs.

Rural space modeling was the one of the main topics of scientific debate during the 36th International Seminar on Rural Geography organized by the University of Warmia and Mazury in Olsztyn on 21–22 June 2021 in Olsztyn, Poland.

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References

1. Kurowska, K.; Marks-Bielska, R.; Bielski, S.; Aleknavičius, A.; Kowalczyk, C. Geographic information systems and the sustainable development of rural areas. *Land* **2021**, *10*, 6. [CrossRef]
2. Cloke, P.J.; Doel, M.A.; Matless, D.; Thrift, N.; Phillips, M. *Writing the Rural: Five Cultural Geographies*; Sage: London, UK, 1994.
3. Cloke, P.J. (Ed.) *Country Visions*; Pearson Education: New York, NY, USA, 2003.
4. Coburn, A.F.; MacKinney, A.C.; McBride, T.D.; Mueller, K.J.; Slifkin, R.T.; Wakefield, M.K. Choosing rural definitions: Implications for health policy. *Rural. Policy Res. Inst. Health Panel* **2007**, *2*, 1–8.
5. Ilbery, B. Dimensions of rural change. In *The Geography of Rural Change, Ilbery, B., Ed.*; Longman: Harlow, 1998; pp. 1–10.
6. Bański, J.; Mazur, M. Classification of rural areas in Poland as an instrument of territorial policy. *Land Use Policy* **2016**, *54*, 1–17. [CrossRef]
7. Różycka-Czas, R.; Salata, T.; Gawroński, K.; Czesak, B.; Cegielska, K. The use of geographic information systems to spatial order evaluation. *Acta Sci. Polonorum. Form. Circumiectus* **2016**, *15*, 73. [CrossRef]
8. Kamińska, W.; Mularczyk, M. Attractiveness of Central Public Spaces in Small Polish Towns Based on a Spatial Order Analysis. *Land* **2021**, *10*, 1327. [CrossRef]
9. Chen, J.; Wang, C.; Dai, R.; Xu, S.; Shen, Y.; Ji, M. Practical Village Planning Strategy of Different Types of Villages—A Case Study of 38 Villages in Shapingba District, Chongqing. *Land* **2021**, *10*, 1143. [CrossRef]
10. Kopáček, M. Land-Use Planning and the Public: Is There an Optimal Degree of Civic Participation? *Land* **2021**, *10*, 90. [CrossRef]
11. Kurowska, K.; Kietlinska, E. Spatial planning as a tool for rural area management. In Proceedings of the Geographic Information Systems Conference and Exhibition "GIS ODYSSEY 2017", Trento, Italy, 4–8 September 2017; p. 221.
12. Kurowska, K.; Kryszk, H.; Marks-Bielska, R.; Mika, M.; Leń, P. Conversion of agricultural and forest land to other purposes in the context of land protection: Evidence from Polish experience. *Land Use Policy* **2020**, *95*, 104614. [CrossRef]

13. Kowalczyk, C.; Kil, J.; Moldovan, C.S. Comparison of changes in urbanized areas in Poland and Romania. *Transylvanian Rev.* **2018**, *2*, 7.
14. Parry, J.A.; Ganaie, S.A.; Bhat, M.S. GIS based land suitability analysis using AHP model for urban services planning in Srinagar and Jammu urban centers of J&K, India. *J. Urban Manag.* **2018**, *7*, 46–56. [CrossRef]
15. Kowalczyk, C.; Kil, J.; Kurowska, K. Dynamics of development of the largest cities—Evidence from Poland. *Cities* **2019**, *89*, 26–34. [CrossRef]
16. Kurowska, K.; Kryszk, H.; Marks-Bielska, R.; Kietlińska, E. Spatial analysis of afforestation in Poland under Rural Development Programme 2007–2013. In Proceedings of the Annual 20th International Scientific Conference Proceedings Research for Rural Development 2014, Jelgava, Latvia, 21–23 May 2014.
17. Kurowska, K.; Kryszk, H. Profitability of the farmland afforestation within the Rural Development Programme. *Sylwan* **2017**, *161*, 1035–1045. [CrossRef]
18. Kurowska, K.; Kryszk, H.; Gwiaździńska-Goraj, M. Sustainable development of coastal areas-Polish experience following accession to the European Union based on the example of Fisheries Local Action Groups (FLAGs) during 2007–2013. *Acta Adriat.* **2014**, *55*, 2.
19. Kurowska, K.; Rudnicki, R. Changes in land use in Poland—Comparative study of period 2002–2010. In Proceedings of the 7th International Scientific Conference Rural Development 2015: Towards the Transfer of Knowledge, Innovations and Social Progress, Kaunas, Lithuania, 19–20 November 2015. [CrossRef]
20. Jukneliené, D.; Kazanavičiūtė, V.; Valčiukienė, J.; Atkocevičienė, V.; Mozgeris, G. Spatiotemporal Patterns of Land-Use Changes in Lithuania. *Land* **2021**, *10*, 619. [CrossRef]
21. Mozgeris, G.; Jukneliené, D. Modeling Future Land Use Development: A Lithuanian Case. *Land* **2021**, *10*, 360. [CrossRef]
22. Stręk, Ż.; Leń, P.; Wójcik-Leń, J.; Postek, P.; Mika, M.; Dawid, L. A Proposed Land Exchange Algorithm for Eliminating the External Plot Patchwork. *Land* **2021**, *10*, 64. [CrossRef]
23. Jurjević, Ž.; Zekić, S.; Đokić, D.; Matkovski, B. Regional Spatial Approach to Differences in Rural Economic Development: Insights from Serbia. *Land* **2021**, *10*, 1211. [CrossRef]
24. Rudnicki, R.; Wiśniewski, Ł.; Biczkowski, M. A Spatial Typography of Environmentally Friendly Common Agricultural Policy Support Relevant to European Green Deal Objectives. *Land* **2021**, *10*, 1092. [CrossRef]
25. Kupren, K.; Hakuć-Błażowska, A. Profile of a Modern Hunter and the Socio-Economic Significance of Hunting in Poland as Compared to European Data. *Land* **2021**, *10*, 1178. [CrossRef]

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Article

Attractiveness of Central Public Spaces in Small Polish Towns Based on a Spatial Order Analysis

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Abstract: The purpose of this article is to evaluate the attractiveness of centrally located public spaces (main squares) in select new small towns in Poland. The evaluation was conducted from the spatial order perspective. Spatial order is composed of five elements: architectural and urban planning, functional, aesthetic, social, and "green" orders. The new small towns included in this analysis are settlement units, which in 2020 were populated by up to 20,000 inhabitants and received municipal rights in the 21st century. We used the point bonitation method in our research based on the source material collected during a field study. A total of 286 inventory cards of buildings and nine cards of town squares were compiled. The analysis demonstrated that the main squares in the towns studied are characterised by low or average levels of attractiveness from the spatial order perspective. The architectural–urban planning order in the towns in question was related to the number of inhabitants as well as the period over which a given settlement unit had municipal rights. A larger number of inhabitants had a positive influence on the functional diversification of the central squares and their development, whereas a small number limited both the functional diversification and the number of small architectural elements found at the square. The social order in the given towns was not connected to the number of inhabitants. The elements of social order were assessed favourably, both in larger towns that revitalised their central squares and in smaller settlements. The aesthetic and green orders were strongly related to the revitalisation of public space.

Keywords: public space; town square; small towns; spatial order; Poland

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1. Introduction

Public spaces have always been a significant element of urban tissue [1]. Take the Greek agora, the Roman forum, or the Italian piazza as examples. However, as pointed out by Jalaladini and Oktay [2], studies on them have been neglected for a long time, mostly due to the adverse effects of urban planning. Those effects became particularly visible in the 20th century, when towns were built and developed to cater to the needs of growing vehicle traffic rather than to satisfy human needs [2–4]. We should keep in mind that "towns are places where people meet to share ideas, trade or simply rest" [5]. Public spaces are areas of social interactions [2,6]. Therefore, in the second half of the 20th century, many urban planners started to take the human dimension of public spaces into consideration [4]. Such a social approach to public spaces focused the scientific debate around actions aiming to increase their attractiveness and, as a consequence, to improve the quality of life for local inhabitants.

Ever since ancient times, public urban spaces have been used for political, military, economic, religious, and sports purposes [7]. Perhaps that is why various authors believe that public space is a basic factor used to confirm the urban character of a place and that a town or city cannot exist without shared, commonly accessible spaces [2,4,8]. Naturally, the forms, arrangement, and functions of public spaces have changed over time [9,10]. Nowadays, they are primarily used for leisure purposes [11].

Despite its long history, public space has several commonly accepted definitions, which probably resulted from the different perspectives taken by researchers from different fields of science [12] as well as from the diversity of these spaces [13]. For instance, Walzer [14] claimed that public spaces are spaces we share with people we do not know and who are not our relatives, friends, or co-workers, whereas Tibbalds [15] believed that public space is constituted by all parts of urban tissue to which the community has unlimited access. Lorens [16] (p. 83) understood this concept as "a fragment of space which, through the way it is organized and located within the urban structure, is used to enable the participants of social life to communicate directly and to fulfil other social needs of the community, remaining at the same time physically accessible for all those interested".

Many authors stress that public spaces characterise the identity and functions of a settlement unit [17], represent the inhabitants' standard of living, create the town's image, and make it more attractive for tourism, settlement, and investment [18–21].

Public spaces are created by many actors: politicians, self-governing activists, architects and planners, residents, and tourists. Public spaces consist of two subsystems: an urban system—consisting of material, anthropogenic, and natural elements of the town, and a social system—consisting of users of the town and their needs, opinions, and perceptions [8].

From the social point of view, public spaces should be accessible, fair, and safe and should ensure comfort and pleasure [4]. In the literature, we can find concepts of physical and visual accessibility [4]. Physical accessibility enables people to enter public spaces without difficulty and to take advantage of its functions, whereas visual accessibility makes watching everything happening in a given space easier [2]. Fairness of a public space means that it has features such that it can fulfil the needs of various social groups [22]. A safe public space protects its users from physical harm (natural disasters, car accidents, and crime) and also provides them with psychological safety (privacy, and not feeling socially or physically lost) [2,11,22]. A properly designed public space should allow a user to walk (walking space, a lack of physical obstacles, good-quality pavements and alleys for walking), sit (zones for sitting and benches to rest on), stand and stay (structures to lean against), look around (reasonable visual distances with open, interesting views and lighting at dusk), speak and listen (low levels of noise), and play and exercise (facilities for physical activity, working out, and playing). The users' pleasure should come from positive sensual impressions (good design and details, beautiful views, trees, plants, and water) [4].

Thus, public spaces should be functionally diversified, i.e., users can perform various activities.

Research on public spaces in towns of different sizes has shown that the accessibility and functionality of these spaces should theoretically be the same or at least similar. In practice, regarding both accessibility and functionality, as well as the aesthetic and ecological aspects, the differences are so large that they form the specific character of public spaces in small towns [23,24]. Generally, the accessibility of central public spaces in small towns is better than that in large urban centres due to urban centres being large and heavily populated [25]. Additionally, the level of functionality in public spaces in small towns is lower than that in large and medium-sized towns [26,27].

Although the literature on the subject provides relatively abundant knowledge about public spaces in large cities [28,29] and medium-sized towns [30,31], they are rarely discussed with respect to small towns [23]. We must not ignore the fact that small towns also make up a significant part of national and regional settlement units in many European countries.

For instance, in Poland, in 2019 there were 722 small towns populated by under 20,000 inhabitants, at 22% of the urban population. After World War II, as a result of dynamic socioeconomic phenomena, small towns underwent multidimensional transformations. Cities with large industrial plants or towns situated close to large factory complexes usually flourished, whereas small, peripheral towns or towns without any significant economic functions fell into states of regression or stagnation [32]. The economic situation had an impact, primarily, on the development and functioning of public spaces. In many small towns, we could observe degradation of the housing tissue and reductions in the functions of public spaces. Only after 1989 (the period of transition from a centrally controlled economy to a market economy and the rebirth of territorial self-government) could we observe a change in attitude towards shaping public spaces in small Polish towns. Local authorities undertook activities aiming to transform the main squares—often devastated and visually unattractive parts of towns—into well-kept areas, satisfying the needs of the local population and revitalising the town. The process was accelerated, on the one hand, due to Poland's accession to the European Union, which provided towns with EU funds for the revitalisation of select spaces, and on the other hand, due to the development of tourism and the resulting necessity to take care of the image of settlement units.

Public spaces may take various forms: a point (an object), a ribbon (a street or the seashore), or an area (a town square or a park). However, in the case of small towns, the town squares have the greatest influence on their identity due to their size and central location. Town squares are where several functions come together: trade, services, housing, administration, and cultural and religious functions [24].

The present spatial order of public spaces is largely related to the historical and economic conditions as well as the demographic potential and location of small urban centres. In towns where the historical (medieval) location of central squares has been preserved, revitalisation, made available with sufficient financial means, helped raise the aesthetic and functional values of the public spaces [33]. In such cases, the old town architecture generally has a positive impact on visual appeal due to the historical heritage of the town square [17]. However, even in such towns, we focus on the limited functionality of buildings, poor aesthetics, and undesirable use of public space (e.g., changing green surfaces into carparks) [17,33].

The relationship between the quality of public spaces in small towns and the level of economic development and location was presented in the study conducted by Konecka-Szydłowska [34]. When studying small towns in the agglomeration of Poznań, she noted that the inhabitants were highly satisfied with the accessibility and functionality of public spaces. This is only natural because a high level of economic development generates high incomes for a given city [35,36], which can be spent on revitalisation and transforming public spaces in accordance with the requirements of a modern society [37–40]. We also stress that people inhabiting small towns situated within the area of influence of huge urban agglomerations are better educated than those in peripheral towns and are more aware of the possibility of satisfying their needs [36,41,42]. The pressure exerted on local authorities with regard to shaping public spaces makes it possible to satisfy the expectations of local communities [25,43]. On the other hand, towns situated on the peripheries and with a modest population potential have underdeveloped public spaces. They are characterised by low functionality, related to the services used by rural inhabitants rather than by urban inhabitants [44–47]. The public space of such towns is used primarily to accommodate businesses providing basic services [48,49]. Additional services occur sporadically, which is natural, because for every settlement unit to develop economically, a minimum population potential is needed: on the one hand, a market, and on the other hand, a work force [50,51].

What is interesting from a cognitive point of view are the changes in the functions and development of the main squares in the settlement units that lost and regained municipal rights (in Poland, a town is a settlement unit that possesses municipal rights, granted administratively by the Council of Ministers. The decision to give a town this status is based on five criteria. The main one is the number of inhabitants. As a rule, a town should have a minimum of 2000 inhabitants. However, in practice, many exceptions to this rule exist. An important exception is having been granted municipal rights in the past. The remaining criteria include the following: at least 60% of inhabitants must make their living from non-agricultural activity, urban areas of the town should not have farming buildings, a separate centre should be identifiable, and the necessary technical infrastructure, i.e., water and sewage systems, should be available). In such towns, the attractiveness of the public spaces is particularly important to inhabitants who typically develop close interpersonal relationships based on their knowledge of places and local communities [21,52].

In light of the remarks above, the purpose of this article is to evaluate the attractiveness of central public spaces (town squares) in select new small towns in Poland. The new small towns presented in the article are settlement units that received municipal rights in the 21st century and are populated by up to 20,000 inhabitants.

The attractiveness of town squares as public spaces was evaluated in the form of an expert assessment on the basis of direct observations (a field study). The evaluation was made from a spatial order perspective, including five elements: architectural–urban planning, functional, aesthetic, social, and green (ecological) orders. At this stage of the study, the inhabitants' opinions or needs were not considered. These will be the objects of further research.

We assumed that a town square is the town's central square surrounded by buildings [53], which consists of the surface of the town square as well as shared zones, i.e., public streets and pavements running along the edges of the town square, including the accompanying infrastructure [26].

The specific objectives of the article include evaluating the spatial order of the main squares in select new small towns in Poland and rating the architectural–urban planning, functional, social, aesthetic, and green orders, and evaluating the attractiveness of the town squares in select new small towns in Poland.

The article also has a practical purpose. The collected empirical material, if supplemented with the opinions of public space users (inhabitants and tourists) may provide a basis for introducing changes in the spatial order of the town squares in question in order to raise the attractiveness of public spaces in general. In addition, we provide further directions in the research on public spaces in small urban centres.

The results presented below fill the gap in the research on the functions and attributes of public space in units that, for decades, have functioned as rural areas, with predominantly agricultural functions.

2. Research Area

The study included nine Polish towns in Świętokrzyskie province (Figure 1), which is one of the few regions in Poland where the rural population is larger than the urban population. It is among the smallest and least developed regions in the country (Eastern Poland), with the lowest socioeconomic development indexes in the whole European Union. In order to decrease the differences between Eastern Poland and the remaining parts of the EU, a special development program was launched (Eastern Poland). Another characteristic feature of the province is a poorly developed settlement network. In 2019, 44 towns, 39 of which were small towns, were populated by under 20,000 people. The number of towns and their sizes in this region are unfavourable. According to research, urban centres have a considerable influence on the economic development of the surrounding rural areas, and the larger the town, the stronger and more widespread the influence [32,51]. Świętokrzyskie province is an example of a region where the development of rural areas is artificially reinforced by granting municipal rights to small settlement units.

The towns in question share several characteristic features. First, they all belong to a group of small (very small) destinations. In 2020, the number of inhabitants ranged from 338 in Opatowiec to 3167 in Radoszyce (Table 1). This group includes the two smallest towns in Poland: Opatowiec and Wiślica (515 inhabitants). Second, all of the settlement units in question have already been given the status of a town in the past. The towns granted municipal rights the earliest (13th century) were Nowy Korczyn, Koprzywnica, and Opatowiec, whereas the one granted municipal rights the latest (16th century) was Daleszyce. Third, all of the destinations in question lost their municipal rights in the 19th century (1869–1870) due to a tsar's edict, as punishment for participating in the January Uprising (at that time, Poland had been partitioned. The towns in question were situated in the Kingdom of Poland, which was connected to the Russian Empire due to a personal union).

Figure 1. The location of the towns studied in Poland and Świętokrzyskie province. Source: authors' own elaboration.

The studied settlement units functioned as towns for several hundred years. Such a long period enhanced urban features, and the towns developed some functional ties with the vicinity, mostly providing services for their agricultural hinterland [54]. Due to the short distances between them, the towns required services for only a small area, which hampered their growth. Some of them performed other important functions. For instance, Wiślica was a centre for Polish nobility assemblies and Nowy Korczyn was where general councils of Małopolska province started to gather in the 15th century [54]. Nowadays, these places perform mainly administrative and service functions; however, some of them have well-developed tourism (Nowa Słupia and Wiślica).

Another common feature between these settlements is that they regained their municipal rights in the 21st century. First, Daleszyce was reinstated as a town (2007); then, Stopnica was reinstated (2015). The remaining destinations obtained their status as a town in 2018–2019. This means that the majority of the urban units studied have been functioning as towns for only the last three to four years.

It is also worth mentioning that these towns struggle with demographic problems. Since they regained their municipal rights, their population has decreased (a drop by 2–3%) due to natural loss and migration outflow [32]. The shrinking of the demographic potential decreases the level of entrepreneurship, which, in turn, results in smaller incomes and multiple social problems [35]. In addition, population ageing has become evident. In 2020, the percentage of people at the post-productive age (65+) exceeded 20% in most towns, with the only exception being Daleszyce, where senior citizens made up slightly under 19%. In contrast, in Opatowiec, nearly every third resident was at a post-productive age.

Table 1. Basic information about the studied towns.

Town	Population in the Year in Which They Regained Their Municipal Rights	Population in 2020	Population Dynamics (%)	Period Granted Municipal Rights in the Past	Year in Which Municipal Rights Were Regained	Area (km^2)
Daleszyce	2936	2856	97.3	1569–1869	2007	15.5
Koprzywnica	2488	2431	97.7	1268–1869	2018	17.9
Łagów	1587	1543	97.2	1375–1870	2018	8.2
Nowa Słupia	1373	1356	98.8	1351–1869	2019	14.0
Nowy Korczyn	938	904	96.4	1258–1869	2019	7.5
Opatowiec	338	336	99.4	1271–1869	2019	5.5
Radoszyce	3167	3095	97.7	1370–1870	2018	17.2
Stopnica	1455	1414	97.2	1362–1869	2015	4.6
Wiślica	515	506	98.3	1326–1870	2018	4.7

Source: date from the Local Data Bank (Central Statistical Office) and provided by town and *gmina* offices.

3. Materials and Methods

This study was divided into three stages: literature review, spatial order analysis, and a catalogue of town squares. The first stage involved studying the literature on the subject: public space planning in small towns, the functions and attributes of public space, and the methods of examining it. Based on the above, the aims of this work and the research questions were formulated.

The second stage involved establishing a set of indicators that define individual elements of the spatial order. The list of indicators was compiled based on the literature review and on discussions with experts about spatial planning, landscape shaping, urbanism, spatial economy, and socioeconomic geography. At this point, our own experiences and reflections as well as our familiarity with the research area were also very helpful. For many years, we have conducted research on various aspects of local and regional developments in Świętokrzyskie province, including the growth of the settlement network and rural areas [36,51,55]. We also cooperate with local self-governments and NGOs, designing developmental strategy for rural areas and tourism in this region.

The spatial order perspective was chosen because it allows for a combination of quantitative and qualitative indicators and also creates the possibility to evaluate public space from different points of view.

The attractiveness of town squares is understood as a set of urban planning–architectural, functional, social, aesthetic, and ecological features, enabling the largest possible group of users to use the public space. The principal method of evaluation was point bonitation, where a certain number of points is ascribed to individual features determining the attractiveness of the public space. Next, the points allocated to individual elements were summed up. The advantage of this procedure is that a synthetic result is obtained, which makes it possible to compare the scores obtained for the main squares in the studied towns. Moreover, this method enables the researchers to assess the features of different titres [56–58] and to run a reassessment based on new criteria, expressed by means of a different bonitation scale [56,59]. However, what often raises doubts is the choice of features and value scales adopted for them, depending on the experts' knowledge, experience, and opinions [56,59]. The point bonitation method has been used in scientific research for the evaluation of tourist attractiveness of spatial units [60,61], natural resources [58,59,62], geodiversity [56], soil quality and varieties [57,63,64], as well as spatial valorisation of land cover and objects of nature protection [65]. It is also referred to as [56] rating score [57], bonitation score [63], scoring system [66], or weighting [67,68]. The authors are aware that this method is, to a certain degree, subjective, but this is not uncommon among qualitative methods used in scientific research [61,69–72].

Next, the town square attractiveness index was calculated according to the following formula:

$$WA = \frac{\text{The number of allocated points}}{\text{Maximal number of points}}$$

The attractiveness index ranged from 0 to 1, where 0 signifies the lowest attractiveness (it lacks attractiveness; 0 points within the framework of this research procedure) and where 1 is the highest attractiveness (maximum score). Using its value as a criterion, the authors distinguished town squares of high, medium, and low attractiveness in the following way:

1. $AI \geq 0.6$—high attractiveness;
2. $0.4 \leq AI < 0.6$—medium attractiveness;
3. $AI < 0.4$—low attractiveness.

The attractiveness index made it possible to reduce the number of points allocated to the town squares studied for individual types of spatial order to 0–1 as well as to indicate to what extent the spatial order of public spaces in a given town meets the maximum threshold conditions proposed in this study. A similar technique has been used in scientific research before, bringing positive results [73,74].

It was assumed that spatial order is the structures within the area that form a harmonious whole and takes into account, in orderly relationships, all the architectural–urban planning, functional, social, aesthetic, and ecological conditions and requirements [16,34,75].

It has previously been stated that spatial order consists of five elements.

3.1. The Architectural–Urban Planning Order

The architectural–urban planning order is defined by the degree of spatial structural compactness (including residential areas), the cleanliness, the way the buildings are distributed, and their shape and size [76]. Another important aspect is the technical state and the condition of the existing housing tissue, the adopted building convention, the structure and proportions of the buildings, their location in relation to the street, and the colour of the elevations [77–79].

The architectural–urban planning order of the town squares was analysed based on the following elements: the shape and size of the square, the compactness of the buildings surrounding the square, the type of buildings, maintenance of the building alignment, the condition and colour of elevations, the number of overground storeys, and the occurrence of small architectural elements.

In small towns, the main square is densely built up [80]. Therefore, it should have an adequate shape and size. To be design friendly and easily accessible, the town square should have a regular—square or rectangular—shape. According to Gehl [11], its size should ensure the possibility of fulfilling various, often contradictory, needs (e.g., for intimacy and contact with other people, or for peace and quiet as well as fun, at the same time). In order to evaluate the chosen town squares, they were divided into those being regular and irregular in shapes as well as into large, medium-sized, and small squares. Large squares of a regular shape were allocated more points. Under some circumstances, an irregular shape was compensated for by the size of the square. The scores are presented in Table 2.

The next feature assessed was the compactness of residential buildings. A building facing the town square from the front is considered prestigious. Therefore, plots of land in this part of the town are usually among the most expensive. A feature of a well-developed space around the town square is the high density of buildings and a lack of unoccupied plots, which not only has an impact on the visual effect but also creates an opportunity to diversify economic activity. The lack of vacant plots of land is particularly important in small towns, as such plots are usually unesthetic and spoil the view of the whole square. We distinguished residential buildings of high, medium, and low compactness (Table 3).

Table 2. Town square shapes and sizes—evaluation criteria.

Town Square Shape	Square Size (Area, Including Streets and Pavements)	Number of Points
Regular (square and rectangular)	Large (over 10,000 m^2)	3
	Medium (5100–1000 m^2)	2
	Small (up to 5000 m^2)	1
Irregular	Large (over 10,000 m^2)	2
	Medium (5100–10,000 m^2)	1
	Small (up to 5000 m^2)	0

Source: authors' own elaboration.

Table 3. Architectural–urban planning order—evaluation criteria.

Feature	Compactness	Criterion (% of Empty Plots in Relations to the Number of Buildings along the Town Square Frontage)	Number of Points
Building compactness	High	No vacant plots	2
	Medium	0–20% of vacant plots	1
	Low	Over 20% of vacant plots	0

Source: authors' own elaboration.

The next feature taken into account when evaluating the architectural–urban planning order was the type of buildings. The buildings were divided into detached, single-family houses; semi-detached or terraced houses; multi-family houses; and other buildings (e.g., temporary constructions) [78].

Single-family detached houses were rated the best. However, as town squares are space with special, compact structures of buildings, terraced or semi-detached houses should be regarded highly. For this study, we focused on the degree of uniformity between the residential buildings. At the same time, it is worth paying attention to so-called temporary constructions (pavilions, kiosks, and caravans adapted to trading activity). They usually do not look attractive, do not match other buildings, and negatively affect the view of the whole town square. We distinguished between uniform buildings, non-uniform buildings with a small share of temporary constructions, and non-uniform buildings with a large share of temporary constructions (Table 4).

Table 4. Type of buildings—evaluation criteria.

Feature	Criterion	Number of Points
Uniform buildings	Over 60% of buildings of the same type (single-family detached, single-family terraced or semi-detached, or multi-family) in the total number of buildings; less than 5% of temporary constructions	3
Non-uniform buildings with a small share of temporary constructions	No predominant type of buildings; less than 10% of temporary construction in the total number of buildings	2
Non-uniform buildings with a large share of temporary constructions	No predominant type of buildings; more than 10% of temporary construction in the total number of buildings	0

Source: authors' own elaboration.

Another important feature is the maintenance of building alignment. An imaginary line demarcates the distance between the building and the frontage border. Local spatial development plans usually impose a binding and impassable building alignment [78].

In this study, we refer to the line demarcated by adjacent buildings. Maintaining this alignment has an influence on the aesthetic value of the town square and organises the surroundings (pavements, driveways, etc.) (Table 5).

Table 5. Building alignment and structure—evaluation criteria.

Feature	Criteria	Number of Points
Maintaining building alignment	Maintained building alignment (100% of buildings stand along one line)	2
	A curbed line of buildings (two curbs in the whole line of buildings are accepted)	1
	The alignment of buildings is not maintained (more than two curbs in the whole line of buildings around the square)	0

Source: authors' own elaboration.

The next significant feature of the architectural–urban planning order assessed was the condition and colour of buildings' elevations. The state of the building is often related to its age. The front colour, however, is a controversial problem. Although it is generally assumed that flashy colours on buildings are distasteful and disturb the architectural–urban planning order, in recent years, the idea of *pastelosis* has grown. It was introduced by F. Springer [81], describing negative phenomena in the space of Polish towns and cities. *Pastelosis* is an effect of the thermal modernisation of Polish houses with the use of Styrofoam, which is later painted with pastel colours. We distinguished four categories of buildings based on their condition and colour (cf. [78]) (Table 6).

Table 6. The condition and colour of buildings' elevations—evaluation criteria.

Feature	Criterion	Number of Points
Well-kept and subdued buildings	• Over 90% of buildings were described as well-kept and subdued; • Up to 10% of buildings were described as neglected and subdued; and • No buildings were described as flashy, neglected, and non-uniform.	3
Relatively well-kept and subdued buildings	• At least 75% of buildings were described as well-kept and subdued; • Up to 25% of buildings were described as neglected and subdued as well as flashy, neglected, and non-uniform.	2
Neglected and subdued buildings	• Less than 75% of buildings were described as well-kept and subdued; • At least 25% of buildings were described as neglected and subdued as well as flashy, neglected, and non-uniform, with most described as neglected and subdued.	1
Very neglected, brightly coloured, non-uniform buildings	• Less than 75% of buildings were described as subdued and well kept; and • At least 25% of buildings were described as neglected and subdued as well as flashy, neglected, and non-uniform, with most described as flashy, neglected, and non-uniform.	0

Source: authors' own elaboration.

It is also important to consider uniformity with regard to the height of the buildings standing along the town square frontage, measuring it using the number of storeys. Multi-storey buildings around the town square make it possible to diversify functions, which is beneficial both to the owners of the buildings and to the residents. However, from an architectural–urban planning order perspective, it is important to achieve uniformity with regard to the height of the buildings. The scores allocated for this feature are presented in Table 7.

Table 7. The diversity in the height of the buildings—evaluation criteria.

Feature	Criterion	Number of Points
Significant number of two- and three-storey buildings (including a usable attic)	Over 75% of buildings have two or more storeys	2
Many two- and three-storey buildings (including a usable attic)	51–74% of buildings have two or more storeys	1
Mostly one-storey buildings	Over 50% of buildings have one storey	0

Source: authors' own elaboration.

The last evaluated feature in this order was the number of small architectural elements placed in the town square. These included religious elements (chapels and saints' figures), statues, and utility elements for everyday recreation (sandpits and swings) and for sanitation (litter bins) (Table 8). (According to the Construction Act from 1994 [82], small architectural elements are a set of small construction objects serving area-development purposes. Basic types of small architectural elements include (1) religious cult objects (e.g., chapels, roadside crosses and figures), (2) garden objects (e.g., statues and fountains), and (3) utility objects, for daily recreation (e.g., sandpits, swings, and benches) and for sanitation (e.g., litter bins).) Other small architectural elements are discussed when evaluating the spatial order. The criteria for allocating points were established based on the distribution of features in the towns in question.

Table 8. The occurrence of small architectural elements—evaluation criteria.

Feature	Criteria	Number of Points
A large number of small architectural elements	6 or more elements per 1000 m^2 of the area of the town square	3
An average number of small architectural elements	4–5 elements per 1000 m^2 of the area of the town square	2
An insignificant number of small architectural elements	3 elements or fewer per 1000 m^2 of the area of the town square	0

Source: authors' own elaboration.

The total number of points allocated for the architectural–urban planning order ranged from 0 to 18.

3.2. The Functional Order

The second category of the spatial order is the functional order, referring to the comfort of living, and the co-occurrence of various functions and relations among them, such as the occurrence of service, education, and recreation facilities. A properly designed town square should ensure that regular everyday activities (e.g., going to work, to the shop, and to the bus stop), optional activities (e.g., going for a walk and using small architectural elements), and social activities (e.g., having meetings, conversing, and carrying out all kinds of activities) can be performed [11].

In order to evaluate the functional order of town squares in the towns studied, we used the following measures: the number of service outlets per 100 m of frontage length, the percentage of storeys with higher-order services out of the total number of storeys, the percentage of vacancies out of the total number of storeys, and the ratio of apartments on the ground floor to the total number of buildings. The higher-order services included financial (banking and insurance), legal, advertising, IT, realty, and health care services (doctor and dentist) (cf. [26]). The evaluation criteria were established based on the distribution of individual features in the towns in question (Table 9). The exception was the number of service outlets per 100 m of frontage length. In this case, the authors used the criteria proposed by Gehl [11].

Table 9. Evaluation criteria for the functional order.

Measure	Town Square Categories	Evaluation Criteria	Number of Points
No. of service establishments per 100 m of frontage length [26]	Attractive	15–20 service points per 100 m	4
	Pleasant	10–14 service points per 100 m	3
	"Somewhere in between"	6–9 service points per 100 m	2
	Boring	2–5 service points per 100 m	1
	Unattractive	1 service point per 100 m of the frontage or no services	0
Percentage of service points in the number of storeys	High	Over 60%	2
	Medium	30–60%	1
	Low	Under 30%	0
Percentage of places offering higher-order services in the number of storeys	High	Over 10%	2
	Medium	5–10%	1
	Low	Under 5%	0
Percentage of vacancies in the number of storeys	High	Over 10%	0
	Medium	5–10%	1
	Low	Under 5%	2
The ratio of ground floor apartments to the total number of buildings	High	Over 33%	0
	Medium	10–33%	1
	Low	Under 10%	2
Total number of points			0–12

Source: authors' own elaboration.

3.3. The Social Order

The third element of the spatial order is the social order, which refers to individual and collective identification with places and spaces as well as social bonds [83]. It is important that public spaces be accessible without restrictions, ensure safety for their users, and provide all kinds of facilities needed to spend time there and to develop social contacts. The measures and criteria for social order evaluation are presented in Table 10.

3.4. The Aesthetic Order

Another element of the spatial order is the aesthetic order. It is the most subjective category, as it refers to the beauty of the town square space. According to Encyklopedia PWN [84], to be aesthetically pleasing means to have a pleasant, stylish look, a sense of beauty. It is difficult to state clearly what "beautiful" means. U. Eco [85] claimed that a beautiful thing is something that makes us happy if it is ours but remains beautiful even if it belongs to someone else. Bierwiaczonek [86] notes that it is commonly assumed that beauty is not what is beautiful but what is attractive to individuals. He adds that what people like usually follows the spirit of contemporary times and the ideal of beauty developed in a given epoch. It can be generally assumed that every culture has its own set of composition rules, shared by a given community [87]. It is often stated in the literature that the aesthetic order depends on the richness of information, cleanliness, and colourfulness, as well as symbols facilitating orientation and skilful navigation [88]. Therefore, in order to evaluate the aesthetic order, we adopted measures defining the level of cleanliness, the aesthetics of advertisements, and the general aesthetic impression of the town square. They were evaluated independently using a seven-degree Likert scale, where 1 signified total neglect, the highest unattractiveness (ugliness) of advertisements, and the highest unattractiveness (ugliness) of the town square space, and 7 meant cleanliness, aesthetic advertisements, and a very attractive square space. We visited the squares studied twice: in the late autumn (end of October 2020) and in the summer (July 2021). The evaluation was based on the mean ratings by two authors on both trips (Table 11).

Table 10. Measures and criteria for social order evaluation.

Feature	Measure	Type	Criteria	Number of Points
Accessibility/Availability	Number of streets leading to the town square	High Average Low	6 or more 4–5 2–3	2 1 0
	Amenities for people with disabilities (parking spaces and ramps)	Spaces with amenities Spaces without amenities	At least one amenity No amenities	1 0
	Number of parking spaces for bicycles per 1000 m^2 of the town square	High availability Average availability Poor availability	More than 2 1–2 Less than 1	2 1 0
	Number of streetlamps per 1000 m^2 of the whole square (the town square together with streets and pavements)	Good lighting Medium-quality lighting Poor lighting	More than 5 3–5 Less than 3	2 1 0
	Number of parking spaces (for cars) per 1000 m^2 of the whole square (the town square together with streets and pavements)	High availability Average availability Poor availability	More than 7 5–7 Less than 5	0 1 2
Safety	Public and private monitoring	Space with public or/and private monitoring	At least 1 camera directed towards the square	1
		Space without public or/and private monitoring	No cameras	0
	Police station	Space with a police station	Police station directly at the town square frontage or at the streets leading to it	1
		Space without a police station	No police station directly at the town square frontage or at the streets leading to it	0
	Number of pedestrian crossings per 100 m around the square	Large Average Small	More than 1.5 1.0–1.5 Less than 1	2 1 0
	Technical condition of pavements	Pavements in good technical condition	Over half of the pavement length in a good condition	1
		Pavements in poor technical condition	Over half of the pavement length in a poor condition	0
	Limited traffic	Traffic-free zone	Complete lack of traffic	2
		A zone with limited traffic	Maximum car speed-50 km/h and/or no lorries allowed	1
		Unrestricted traffic zone	No restrictions for traffic	0

Table 10. *Cont.*

Feature	Measure	Type	Criteria	Number of Points
Facilities making public space usable	Number of benches per 100 m^2 of the town square	Large availability Average availability Poor availability	More than 1 0.5–1.0 Less than 0.5	2 1 0
	Number of benches in shaded areas per 100 m^2 of the town square	Large availability Average availability Poor availability	More than 1 0.5–1.0 Less than 0.5	2 1 0
	Number of tables per 100 m^2 of the town square	Large availability Average availability Poor availability	More than 5 1–5 No tables	2 1 0
	Gaming facilities (e.g., chess boards)	Spaces with gaming facilities Spaces without gaming facilities	At least 1 facility No facilities	1 0
	Cash dispensers	Spaces with cash dispensers Spaces without cash dispensers	At least 1 cash dispenser No cash dispensers	1 0
	Public toilets	Spaces with toilets Spaces without toilets	At least 1 toilet No toilets	1 0
	Outdoor restaurants	Spaces with outdoor restaurants Spaces without outdoor restaurants	At least 1 outdoor restaurant No outdoor restaurants	1 0
	Number of walking alleys	Large Average Small	11 or more walking alleys 6–10 walking alleys Less than 6 walking alleys	2 1 0
	Bike paths	Spaces with bike paths Spaces without bike paths	At least 1 bike path No bike paths	1 0
Total				0–28

Source: authors' own elaboration.

Table 11. Evaluation criteria for elements of the aesthetic order.

Feature	Type of Town Square	Criteria	Number of Points
Spatial cleanliness	Very clean	Mean rating on the Likert scale 7	4
	Clean	Mean rating on the Likert scale 6	3
	Medium clean	Mean rating on the Likert scale 4–5	2
	Dirty	Mean rating on the Likert scale 2–3	1
	Very dirty	Mean rating on the Likert scale 1	0
Attractiveness of advertisements	High	Mean rating on the Likert scale 6–7	2
	Average	Mean rating on the Likert scale 3–4–5	1
	Poor	Mean rating on the Likert scale 1–2	0
General aesthetic impression	Very nice	Mean rating on the Likert scale 7	4
	Nice	Mean rating on the Likert scale 6	3
	Average	Mean rating on the Likert scale 4–5	2
	Ugly	Mean rating on the Likert scale 2–3	1
	Very ugly	Mean rating on the Likert scale 1	0
Total			0–10

Source: authors' own elaboration.

The assessment of elements of the aesthetic order was difficult because it was based on subjective feelings. As one English proverb says, beauty (ugliness) lies in the eye of the beholder. However, in order to be more objective, we adopted the principle that an advertisement is attractive (pretty) if it is not damaged, is legible, and is subdued in colour. An unsightly (unattractive) advertisement is one that is illegible, made unprofessionally (by hand), flashy, and disproportionate in terms of size to the content it presents. If unsightly (unattractive) ads accounted for more than 70% of their total number, the advertising layer was assumed to be unattractive and 1–2 points were awarded on the Likert scale. In the case when ugly ads accounted for 30–70% of their total number, the authors allocated 3–5 points, whereas the share of ugly ads in the total number, being less than 30%, was rated the highest, at 6–7 points. In addition, we investigated the number of advertisements (information chaos), their arrangement, and the uniformity in design (cf. [89]). Similar assumptions were made when assessing the overall aesthetic impression that a square made. In the absence of harmony between individual elements of spatial order, visible neglect of the square (broken benches, littered alleys, rusty parts of fountains, lack of greenery, flowers, etc.) was assessed as very ugly, with 1 point awarded on the Likert scale. Along with the authors' growing positive aesthetic impression, the number of points also increased. This stage of research was the most difficult. When can you say that something is ugly (beautiful)? You know it when you see it (the phrase "I know it when I see it" was used in 1964 by United States Supreme Court Justice Potter Stewart [89]) Beauty is a value that entails harmony, moderation, and balance. It requires abundance but not overload, and simplicity but not meagreness or monotony [90].

3.5. The Green Order

The last element of the spatial order in the town squares studied was the green order, referring to valuing the natural environment [83,91]. In order to evaluate the green order of the town squares in small towns, we adopted measures related to the size and type of green areas (trees, bushes, and flower beds) and the presence of small architectural elements, such as fountains and small ponds (Table 12). The criteria for allocating points were based on the distribution of individual features in the studied towns.

Table 12. Criteria in the evaluation of green-order elements.

Feature	Measure	Types	Distinguishing Criteria	Number of Points
Tree density	Number of trees per 100 m^2 of the town square	High	3 or more	2
		Average	2	1
		Low	1 or no trees	0
Shrub density	Number of shrubs per 100 m^2 of the town square	High	2 or more	2
		Average	1–1.9	1
		Low	Less than 1 or none	0
Number of flowers in the town square	Number of flower beds and pots with flowers per 100 m^2 of the town square	High	3 or more	2
		Average	1–2.9	1
		Low	Less than 1 or none	0
Around-the-house greenery	Percentage of houses with flowered lawns or flowers in front of the house in the total number of residential buildings	High	Over 50% of houses had a representational flower bed or flowerpots	2
		Average	30–50% of houses had a representational flower bed or flowerpots	1
		Low	Less than 30% of houses had a representational flower bed or flowerpots	0
Water elements (small ponds and fountains)	Presence of a fountain or small pond	Squares with water elements	At least 1 working fountain or a small pond	1
		Squares without water elements	No water elements	0
	Technical condition and purity of water	High	Mean rating on the Likert scale 6–7	2
		Average	Mean rating on the Likert scale 3–5	1
		Poor	Mean rating on the Likert scale 1–2	0
Total				0–11

Source: authors' own elaboration.

The total of these five elements of public spaces was the basis for the evaluation of their attractiveness in small towns. However, we stress that making a clear classification of all five categories of order is difficult [72]. Some of the measures mentioned above may describe the functional and social, architectural–urban planning, aesthetic, green, social, and functional orders at the same time.

We assumed that all of the features described above are equally important for the spatial order of public space, so we did not diversify them with the use of ranks. This mainly resulted from the fact that public spaces in the studied towns are generally underdeveloped, and some features do not occur at all (e.g., functional elements such as bike paths); diversifying the features by means of ranks was not justified from the point of view of the research process. It should also be noted that the predominant assumption found in the literature on the subject is that all of the components of spatial order are equally important for the functioning of a public space. Without well-developed elements of the urban planning–architectural or social orders, the main squares in small towns would not perform the basic functions of a public space, similar to the ecological and aesthetic orders [33,34,92].

The third stage in the research was a field study, which involved making a detailed catalogue of town squares in the studied towns. The researchers prepared an inventory card for each building, including the measures described above (Table 13). They prepared a total of 286 cards of buildings standing along the town square frontage.

Table 13. An inventory card of a building situated along the town square frontage.

Name of town	
Name of street	
Building number	
No. of overground storeys	
Type of building	Single-family, detached Single-family, semi-detached, or terraced Other (office, temporary, etc.)
Location of the building in relation to the street	Parallel to the street Perpendicular to the street Other
Location of the building in relation to the main building line	Maintaining the main building line Building pushed back from the main building line Building pushed forward from the main building line
Functions	Ground floor 1st floor 2nd floor Other
Condition and colour of elevations	Well-kept, subdued Neglected and subdued Flashy, neglected and non-uniform
Age of the building	Before World War II After World War II, from the 1990s New, modern
Type of foundations	Stone, unplastered Stone, plastered Other besides stone
Greenery near the house	Representational lawn with flowers in front of the house Single plants No greenery near the house

Source: elaboration based on [70].

Additionally, all town squares were inventoried, with particular consideration of the small architectural elements, green areas, intensity and aesthetics of advertisements, etc. Nine such cards were prepared (Table 14).

As the next step, the authors evaluated the attractiveness of the squares according to the adopted criteria and formula and, based on this, drew conclusions.

Apart from the point bonitation method and field study, the researchers used the graphic method, which enabled them to present the shapes and sizes of the town squares as well as their functional diversification.

Table 14. An inventory card of the town square.

Name of Town	
General Information	
Shape of town square	Regular—rectangular Regular—square Irregular Regular—other
Town square size (town hall or/and geoportal info)	Town square surface The whole town square area Length of northside frontage Length of southside frontage Length of eastside frontage Length of westside frontage
Functional Order	
Small architecture elements, including religious objects	Chapels (number) Figures and statues (number) Other (number)
Utility objects used for everyday recreation	Climbing frames Swings (number) Other (what kind?)
Utility objects for sanitation	Rubbish bins (number)
General aesthetic impression	Scale 1 (aesthetic)–7 (highly unaesthetic)
Social Order	
Accessibility	No. of streets leading to the town square Amenities for disabled people (parking spaces, ramps, etc.) No. of parking spaces for bicycles No. of streetlamps No. of parking spaces for cars
Safety	No. of lamps General monitoring Monitoring on private property Police station in the town square or the streets leading to it Even and well-kept pavements Uneven and neglected pavements Quality of pavements No. of pedestrian crossings Traffic restrictions (no car traffic, speed limit, etc.)
Facilities making it possible to use public spaces	Stage and sound system Total number of benches Number of benches in shaded places Number of tables Other facilities (e.g., chess boards) Outdoor restaurants
Identity-related places	Slabs/boulders with plaques commemorating important events Models, photography exhibitions related to the history of the town Other
Facilities encouraging long stays in public space	Working public toilets No. of outdoor restaurants Cash dispensers No. of walking alleys Bike paths

Table 14. *Cont.*

Name of Town	
Aesthetic Order	
Cleanliness in the town square	Scale: 1 (dirty)–7 (very clean)
Graphics	No. of advertisements No. of information boards Aesthetics of adverts: scale: 1 (unaesthetic)–7 (aesthetic)
General aesthetic impression	Scale: 1 (unaesthetic)–7 (aesthetic)
Green Order	
Vegetation	No. of trees No. of shrubs Number of flower beds and lawns
Presence of water elements	Small pond Fountain
Technical condition of water elements and purity of water	Working Idle Cleanliness scale: 1 dirty–7 very clean Purity of water (0–7)

Source: authors' own elaboration.

4. Results and Discussion

The overall score for all elements of the spatial order ranged from 26 to 46 points (Table 15), which means that the studied public spaces received 33–58% of the maximum number of points possible.

Table 15. Points for elements of the spatial order and the town square attractiveness index.

Town	Number of Points for Each Order						Attractiveness Index
	Architectural–Urban Planning	Functional	Social	Aesthetic	Green	Total	
Daleszyce	11	8	15	8	4	46	0.58
Koprzywnica	8	7	9	3	0	27	0.34
Łagów	9	7	16	6	7	45	0.56
Nowa Słupia	7	9	7	3	0	26	0.33
Nowy Korczyn	9	4	18	5	4	40	0.50
Opatowiec	11	3	8	4	3	29	0.36
Radoszyce	11	7	14	6	5	43	0.54
Stopnica	12	7	14	7	4	44	0.55
Wiślica	11	6	14	5	6	42	0.53

Source: authors' own elaboration.

4.1. The Architectural–Urban Planning Order

The score for all elements of the architectural–urban planning order ranged from 7 to 12 points. The maximum number of points was 18 (Table 15), which means low and medium levels of this order were found for the analysed towns. The highest number of points was allocated to the town square in Stopnica (Figure 2), a destination that regained its municipal rights only six years ago. The town square there has a regular shape, close to a square, and its area (together with streets and pavements) covers over 7000 m^2, which places it among medium-sized town squares. The square in Stopnica was allocated 12 out of 18 points (67% of the maximum score). The smallest number of points was allocated to the town square in Nowa Słupia, which has an irregular shape and a small area, slightly over 6000 m^2. It regained it municipal rights in 2019. Generally speaking, the town square in this town was neglected with respect to the architectural–urban planning order. The only highly rated feature was the type of buildings. They were mostly uniform buildings, with few temporary structures. The remaining features were rated poorly, particularly the compactness of the buildings, the condition and colour of the elevations, and the occurrence of small architectural elements. The researchers allocated seven points to this square (39% of the maximum square).

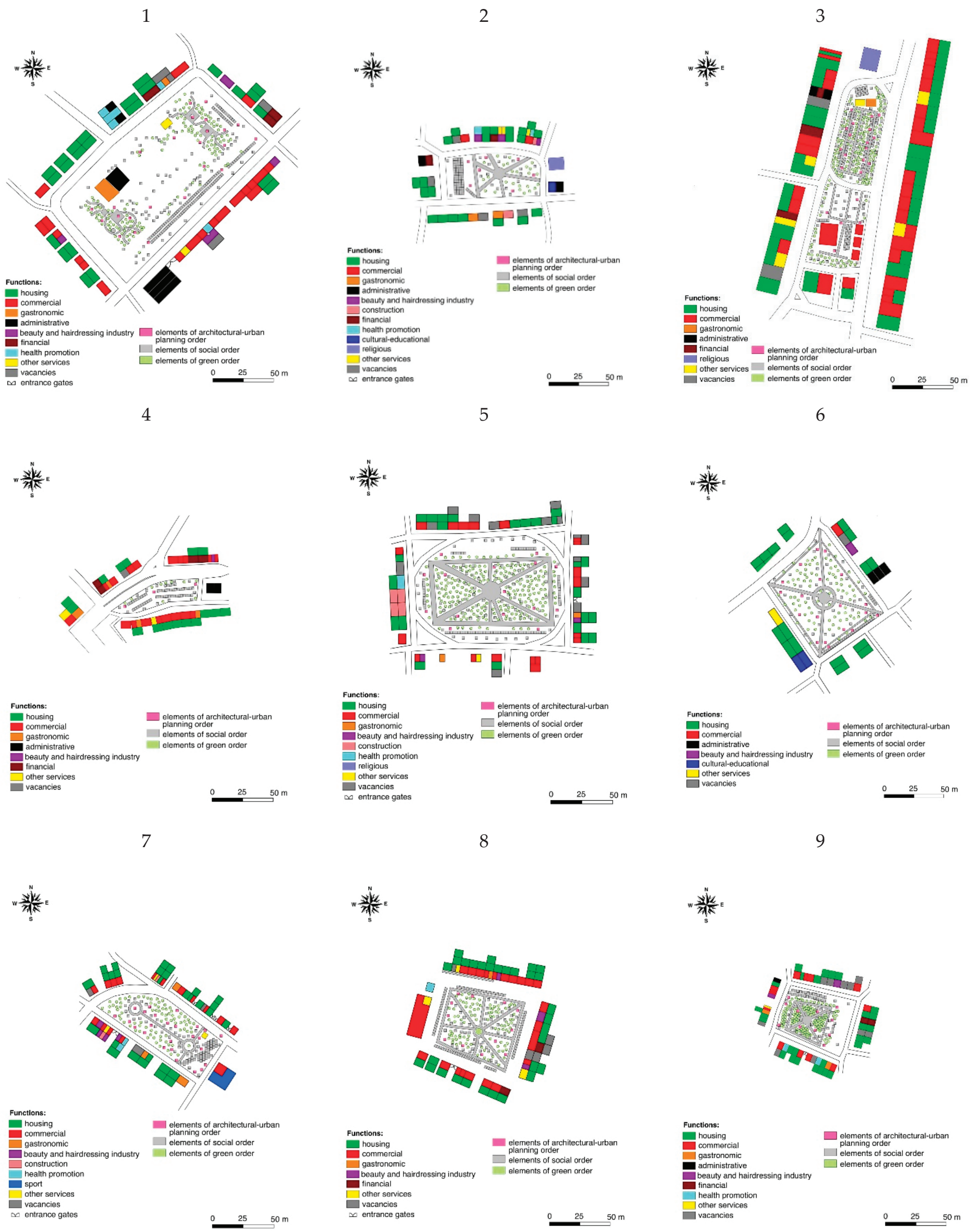

Figure 2. Selected elements of the spatial order of town squares in new small towns. Source: authors' own elaboration. 1—Daleszyce, 2—Koprzywnica, 3—Łagów, 4—Nowa Słupia, 5—Nowy Korczyn, 6—Opatowiec, 7—Radoszyce, 8—Stopnica, 9—Wiślica.

Generally speaking, town squares in the studied towns are regular in shape; the majority of them are small and medium-sized. Only two towns—Daleszyce and Łagów—have rectangular squares of impressive sizes. Both towns were granted subsidies for revitalisation, transforming these spaces according to current trends. The areas of the squares exceed 20,000 m^2.

The weaknesses of all of the town squares were the low compactness of the buildings and large number of undeveloped plots. These weaknesses are convergent with the results of studies conducted by other authors, stressing the insufficient use of space near central squares in small towns [26]. The compactness of the buildings is additionally reduced by drive-in gates, which often disrupt the whole space. Another drawback is the poor state and faded or motley colours of building facades. In nearly all cases, many buildings were neglected and brightly painted, not matching the surroundings. Regrettably, this phenomenon is often stressed in the literature and can be found in the public spaces of towns of different sizes [16]. The amount of small architectural elements was also rated poorly (Figure 2). Only in individual cases could we find figures or statues in the square (in Stopnica, 2; in Daleszyce, 2; and in Wiślica, Nowy Korczyn, Łagów, and Opatowiec, 1). Most pieces of small architecture were for sanitation (litter bins), but they were scarce in the public spaces studied, which has been confirmed by the observations made by other researchers regarding the development of public space in small Polish towns [8,37,39,93,94]. The number of small architectural elements found in town squares is connected to the historical past. They are represented by statues of historical figures and figures of saints, showing people's attitude regarding the Catholic Church and Christian faith. In the towns in question, even historical events are presented in conjunction with characters related to Catholic Church. Czepczyński [8] called this a sacralisation of public spaces and claimed that it is the most pronounced and dynamic socio-spatial process observed in many small towns. They also indicated that many elements of this type are historical and related to the activity of previous generations. Small architectural elements also point to the modern use of financial resources, which are spent to cover the cost of revitalisation (e.g., introducing elements used to maintain cleanliness).

The low evaluation of the architectural–urban planning order is closely connected to the age of the buildings. Many were built before World War II, and the majority were erected in the socialist period (1945–1989), with only a few appearing at the turn of the 21st century. During central planning, the appearances of buildings were not a priority and there were shortages of basic construction materials or finishing elements (external fittings, window and door woodwork, glazing, balustrades, cladding, plasters, and paint coatings) [95]. It is mainly such houses that surround the main public spaces in these towns. The loss of their municipal rights deepened the economic crisis, and in no way did it help to recreate the housing tissue. The age of buildings is also related to the number of storeys. Those built before World War II usually have one storey, e.g., temporary and provisional constructions (pavilions and kiosks). The buildings erected during the centrally planned economy period usually have two storeys, and new buildings have two storeys and a usable attic. Similar features were observed in small towns located in other regions of Poland [17]. The state of the buildings surrounding the squares also worsened due to migration processes. Young people are migrating to larger centres, and those who stay are older and cannot afford to redecorate their houses. It is generally an unfavourable situation because, as Jacobs [3] (p. 29) said, "If a city's streets look interesting, the city looks interesting; if they look dull, the city looks dull."

4.2. Functional Order

The score for the functional order ranged from three to nine points (Table 15). The maximum number of points to be calculated was 12, which means that the studied public spaces received 25–75% of the maximum number of points. Thus, it can be stated that the functional order in the studied towns was at the low and medium level (Table 15, Figure 2). The highest number of points (9) was allocated to the town square in Nowa Słupia, a destination situated on the edge of Świętokrzyski National Park, which concentrates most tourist traffic to the Holy Rood Monastery, an important place in the province and in Poland from historical and religious points of view. From the 13th to the early 19th century, the town was the property of the Holy Rood Benedictine Abbey. For centuries, it developed infrastructure providing services to tourists, which caused a relatively high functional diversification and enabled a large number of establishments to adapt to service functions. The smallest number of points was allocated to Opatowiec (three points)—the least populated town in the country. The buildings standing along the town square frontage did not develop any other function except for the residential one.

The weakness of the functional order of the squares in the studied towns was the generally small functional diversification. The predominant function was trade (5–50% of the overall number of storeys). The shops were usually small groceries or markets, where one can buy all kinds of goods, from toiletries and household chemicals to metal objects and household equipment. It was more typical of rural areas than towns, even small ones. Higher-order services (financial, healthcare, cultural–educational, legal, and advertising) were rare, and they did not occupy more than 11% of the total number of storeys (in most towns, it was 2–5%). A similar phenomenon has been identified by other researchers in various regions of Poland. This is typical of small Polish towns [26]. What is also worrying is the high percentage of vacancies in the buildings surrounding the town square. For instance, in Nowy Korczyn, every fourth storey showed no signs of being used, and in Wiślica, nearly every fifth one. Apart from the fact that they do not have a utility value, vacancies also have neglected elevations and woodwork and, generally, make a bad impression.

The lack of functional diversification makes public spaces boring and not attractive to the inhabitants. Holland et al. [96] found that people are attracted and usually stay longer in public spaces that offer excitement, stimulation, and some comfort. A particularly negative factor affecting the functioning of the town squares in the studied towns is the lack of gastronomic establishments. As indicated by Whyte [97], nothing attracts people to a public space as effectively as the possibility to eat and drink, and a person having a meal in a public space attracts even more people. The town square as a central place should be a concentration of a variety of services. The towns in question have not developed a rich functional structure, remaining rural units. The shrinking population does not encourage the town to expand their service offer.

4.3. Social Order

The score for the social order in the towns analysed ranged from 7 to 18 points. The maximum number of points was 28 (Table 15), which means that the studied public spaces received 25–64% of the maximum number of points. Thus, the social order in the towns studied was also at the low and medium levels. The highest number of points was allocated to the town square in Nowy Korczyn (Figure 2). The town regained its municipal rights in 2019. The whole square has a small area, but many elements, as well as their accessibility and safety for various social groups, have been taken care of. However, it must be stressed that, although many elements function within the space of the square, their availability is definitely insufficient. If we take amenities for people with disabilities, for example, there are parking spaces in the square but only two. According to the regulations [98], there should be a minimum of three such spaces. (The number of parking spaces for people with disabilities in Poland is specified by the Public Roads Act of 21 March 1985 [98]. This number depends on the total number of parking spaces in a given carpark. When a lot has six to 15 parking spaces, one should be reserved for people with disabilities. However, in carparks with 16–40 spaces, a minimum of two spaces must be designated for people with disabilities. In carparks where the total number of parking spaces is 41–100, a minimum of three parking spaces should be dedicated to this group of people. If there are more than 100 parking spaces, 4% of them must be reserved for people with disabilities. There are 70 parking spaces at the square in Nowy Korczyn.) The lowest number of points was allocated to the squares in Nowa Słupia (7) and Opatowiec (8). None of them follow the basic rules of social order, and they do not encourage developing interpersonal relationships. In Nowa Słupia, almost the whole space of the square is used as a parking lot. Similar management approaches have been defined as inappropriate and were also observed in other regions of Poland [17,33,37,39]. Research shows that areas dedicated to car traffic decrease the vitality of public spaces [99]. There are no walking alleys, trees, shrubs, or small architectural elements. A similar situation was observed in Opatowiec. There is inadequate lighting on the square and an insufficient number of pedestrian crossings. There are also no public toilets, ATMs, restaurant gardens, or other elements attracting the inhabitants of the town.

Generally, another weakness of all of the town squares under study was a lack of facilities and elements that would not only attract the inhabitants but also make them stay longer. People tend to stay within public space if they find comfortable seats there, with some kind of protection against bad weather [2]. The small number or complete lack of gastronomic establishments, lack of public toilets or limited access to them, and lack of outdoor restaurants do not enhance the vitality of public spaces. During revitalisation, trees and shrubs were nearly completely removed from the two largest town squares in Łagów and Daleszyce. Despite later attempts, it was impossible to restore the former greenery. As a result, the number of benches in shaded places decreased, which is particularly important, as the majority of the towns' inhabitants are senior citizens.

4.4. Aesthetic Order

The score for the aesthetic order in the towns analysed ranged from three to eight points. The maximum number of points was 10 (Table 15), which means that the studied public spaces received 30–80% of the maximum number of points. The highest number of points was allocated to Daleszyce, which is a destination situated closest to the main city of the province, Kielce, and was the first to regain its municipal rights among the towns in the study (2007). This is important because the town could take advantage of Polish and European funds for revitalisation. From an aesthetic point of view, the town looks very impressive, it is very clean, and the problem of unattractive advertisements is under control.

The lowest rated for aesthetics were the town squares in Koprzywnica and Nowa Słupia. These squares are characterised by an excessive number of advertisements and signboards. They are poorly made, often heavily weathered, and cause information chaos. In Koprzywnica, there are over 10 adverts and signboards per 100 m of square frontage length. The cobbled town square in Nowa Słupia, which has no flowers or greenery, is filled with cars and has practically no strolling or relaxing people in view, and does not have a high degree of spatial order according to this study. Previous research has shown that spaces designed for traffic decrease the vitality of public spaces [6,100]. In addition, as stressed by Jacobs [3] and by Jalaladini and Oktay [2], the decreasing significance of pedestrian traffic in urban public spaces makes them dehumanised and lowers the quality of life for the inhabitants.

4.5. Green Order

The score for the green order in the towns analysed ranged from zero to seven points. The maximum number of points was 11 (Table 15), which means that the studied public spaces received 0–64% of the maximum number of points. The largest number of points was allocated to the town square in Łagów (Figure 2). It is one of the largest squares in the whole province, revitalised in 2013 for nearly half a million PLN (about EUR 120,000). Similar to the majority of revitalised town squares in Poland, in the second decade of the 21st century, nearly all trees and shrubs were cut down and the whole surface of the two square was paved. However, for several years, there have been attempts to restore green surfaces, and in the case of Łagów, it has been partly successful. Unfortunately, the destruction of greenery in public spaces in small Polish cities has virtually become a regular feature of these spaces. Many authors emphasise this negative aspect of shaping central squares in small towns [37,39]. The town square in Nowa Słupia, which is practically devoid of greenery, was allocated zero points for green order (Figure 2).

In Nowy Korczyn, Nowa Słupia, and Pokrzywnica, a lack of greenery was noted outside residents' homes (90%, 87%, and 77%, respectively). Such numbers must be regarded as highly influential on the overall green order of the towns and, therefore, as a weakness in terms of the overall spatial order.

4.6. Attractiveness of the Town Squares

Taking the attractiveness index values into consideration, the town squares in the towns analysed can be divided into two groups: squares of medium and low attractiveness. The first group includes the squares in Daleszyce, Łagów, Nowy Korczyn, Radoszyce, Stopnica, and Wiślica, where the attractiveness index ranged from 0.50 to 0.58. This means that those squares scored about half of the maximum score. This group contains two categories of squares. The first one includes revitalised squares, with well-designed social and aesthetic orders but imperfect green order (Daleszyce (Figure 3), Łagów (Figure 3), Stopnica (Figure 3), and Wiślica (Figure 3). Revitalisation included a good design of the town square and small architectural elements, such as some amenities promoting social contacts (tables, gaming equipment, etc.). The other category encompasses squares that have not been revitalised yet, where natural greenery has not been damaged. In these towns, town squares are characterised by city parks. Due to the number of inhabitants and historical conditions, they have high-quality social and architectural–urban planning orders, which eventually raised the value of the attractiveness index by over 0.5. This category includes the town squares in Radoszyce and Nowy Korczyn.

The other group, consisting of unattractive squares (low attractiveness index, less than 0.4), includes the town squares in Opatowiec, Koprzywnica, and Nowa Słupia. These spaces do not have attributes of urban public spaces. None of the elements of social order have been fully developed.

The characteristic features of these squares include small functional diversity, lack or small number of amenities enhancing social contacts (tables, game boards, walking alleys, and benches), insufficient greenery, poor aesthetics of the frontage buildings, and small area of the central public space.

Public spaces in small towns, which used to be villages just a few years ago, do not seem to be attractive. This seems to be the main cause of the low quality of all attempts at renovation of these spaces. The projects often do not consider the history of the town, its identity, or the needs of its inhabitants. They duplicate previously prepared projects for other towns of similar sizes (and similar numbers of inhabitants) [101]. A lack of stable traditions and models of creating central spaces in small towns lowers their attractiveness. The physical forms of these towns loosely refer to the wishes and needs of the local communities [2]. Watson et al. [102] indicated that town squares shaped in this way do not have a clear, specific character and are only a mixture of styles and themes borrowed from different parts of Poland and the world. Perhaps this uniform pattern of urban spaces results from the fact that such a concept turned out to be a success in the struggle for EU funds, and other local government units, wanting to increase their chances in this race, follow these "good models" [39].

It should also be noted that the results obtained depend, to a large extent, on the method and measures adopted. The bonitation method used in the study and the concept of spatial order allowed us, on the one hand, to assess the attractiveness of the squares of small towns in Poland from a broad perspective, using a rich and varied set of measures. This approach should be assessed positively. On the other hand, the study used a number of qualitative measures that require subjective assessment by researchers (e.g., measures describing the aesthetic order of public space). This means that the results may vary depending on the personality traits of the researchers (e.g., aesthetic feelings, emotional state, and weather conditions).

Figure 3. Town squares. Source: authors' own work. 1—Daleszyce, 2—Koprzywnica, 3—Łagów, 4—Nowa Słupia, 5—Nowy Korczyn, 6—Opatowiec, 7—Radoszyce, 8—Stopnica, 9—Wiślica.

5. Conclusions

The analysis shows that the town squares in the towns studied represent low or medium levels of attractiveness, if seen from the perspective described in this study. This means that the attributes of urban public spaces have been poorly developed. The most attractive squares were the main squares of the largest towns, which regained municipal rights the earliest (Daleszyce, Łagów, and Stopnica). Those towns were able to use the financial means they received for the revitalisation of their squares, and their relatively large population enhanced the functional development of public spaces. Their weakness is in the shortage of green areas, resulting from common revitalisation trends, such as transforming squares from green to paved areas.

The town squares of the settlement units that were granted municipal rights over the last two to three years are usually small in area, and poorly equipped with small architectural elements or places where the inhabitants can meet. Their characteristic features include large green areas, weak functional diversification, and low buildings along the square frontage. These town squares are green decorations in the towns rather than meeting places and local event venues. The small population potential, the ageing population, many years of neglect of the housing substance, and limited interpersonal relations have caused the poor functional development of these squares and the disappearance of generally accepted aesthetic models. These towns do not meet the basic criteria of urbanity (a small population) and will not be able to develop a public space with the features described in the literature review.

In our evaluation, the lowest-rated square was the town square in Nowa Słupia. All of the elements of spatial order differed from the other destinations. It is a space devoid of public space attributes. The town square is a former marketplace, which gradually turned into a carpark, along with the development of tourist functions. For such a square to gain a basic function as a public square, it needs a complete transformation.

In transforming public squares, it is important to note that a public space must be designed to answer the inhabitants' needs and should reference the history and identity of the town. Revitalised town squares may not look the same in all small towns.

The considerations presented concern settlement units that functioned as villages several years ago. Gaining municipal rights in the 21st century created new challenges, both for the inhabitants and the local authorities. One such challenge is the creation of friendly public spaces that represent the town and is a place for social relations.

Based on the analysis of individual elements of the spatial order of town squares in new small towns, the following can be concluded:

1. The architectural–urban planning order in the towns in question was related to the number of inhabitants as well as the period over which a given settlement unit had municipal rights. A larger number of inhabitants (over 1000) had a positive influence on the functional diversification of the central squares and their development (e.g., Daleszyce, Radoszyce, and Stopnica), whereas a small number limited both the functional diversification and the number of small architectural elements found at the square (e.g., Nowy Korczyn, and Opatowiec). Moreover, in towns with a relatively large number of inhabitants, we observed a larger-than-average number of developments of higher-order services (legal, healthcare, and financial) compared to all of the settlement units under study. Those that were granted municipal rights the earliest (six to 14 years ago) managed to reshape their public spaces using EU and domestic funds for revitalising central squares (e.g., Daleszyce and Stopnica) better than the youngest towns (e.g., Opatowiec and Nowy Korczyn). The number of small architectural elements in the squares represented the history of the towns as well as the predominant Christian religion. The small new towns showed clear symptoms of public space sacralisation. The weakness of the architectural–urban planning order was the poor compactness of buildings situated along the square frontages as well as their poor technical conditions. The low compactness resulted mainly from the low value of the plots at the square and the lack of spatial development plans. This mostly concerned the smallest towns, situated peripherally in Świętokrzyskie province, that gained their municipal status in the last two to three years (Koprzywnica, Opatowiec, and Nowy Korczyn). The poor technical conditions of the buildings standing along the square frontage resulted from their age (the majority were built before and right after World War II and from the relatively low financial status of the ageing community), which is now urban but was still rural two to three years ago. The lack of financial resources for repairs fostered permanent degradation of the housing tissue.
2. The social order in the towns studied was not related to the number of inhabitants. The authors rated the elements of the social order in both larger towns that revitalised their squares (Daleszyce, Łagów, and Radoszyce) and in small settlement units that had not started renovations on their public spaces (Nowy Korczyn and Wiślica) highly. Smaller settlement units have a rich history connected to organising noblemen's meetings and general assemblies as early as the 14th century (cf. Section 2). Perhaps the resulting traditions contributed to preserving old amenities and to creating new amenities connected to shaping social relationships.
3. The aesthetic and green orders were largely related to the revitalisation of public spaces. The towns that already revitalised their central squares, liquidating natural greenery and paving the square's surface (e.g., Łagów and Daleszyce), presented high ratings for aesthetic order but low ratings for green order. In those towns, the authorities attempted to revive green areas in public space, but the effects were not always satisfactory. In towns where revitalisation had not yet taken place (e.g.,

Koprzywnica and Opatowiec), the green order of the central squares (natural green complexes) was highly rated, whereas their aesthetic order was rated poorly. The assessment of both orders in towns where central squares had been turned into carparks (e.g., Nowa Słupia) without natural greenery was rated poorly.

4. Creating a friendly public space (according to the requirements presented in the introduction) in small new towns, especially those situated peripherally in agricultural areas, requires time, financial means, vision, and engagement on the part of the local authorities, non-governmental organisations, and the inhabitants.

The research presented here is the first stage in the evaluation of the attractiveness of town squares in new small towns in Świętokrzyskie province. This attractiveness was evaluated from the researchers' point of view. The next stage should include evaluations of these public spaces from the users' perspectives (considering their mental comfort, and physical and hydrothermal existence within public space) as well as the perspectives of formal planning and management organisations (local authorities and politicians). This will make it possible to compare the technical results from this study with the governance-oriented aspects of planning and development for public squares using a technical approach with the opinions of public space users.

The material presented in this article can be used for comparisons by other researchers and practitioners who deal with similar issues. The results of this study may be applicable to small towns in other countries of Central and Eastern Europe that used to belong to the Eastern Block and had similar conditions of socioeconomic development.

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References

1. Stanley, B.W.; Stark, B.L.; Johnston, K.L.; Smith, M.E. Urban open spaces in historical perspective: A transdisciplinary typology and analysis. *Urban Geogr.* **2012**, *33*, 1089–1117. [CrossRef]
2. Jalaladdini, S.; Oktay, D. Urban Public Spaces and Vitality: A Socio-Spatial Analysis in the Streets of Cypriot Towns. *Procedia Soc. Behav. Sci.* **2012**, *35*, 664–674. [CrossRef]
3. Jacobs, J. *The Death and Life of Great American Cities: The Failure of Modern Town Planning*; Random House: New York, NY, USA, 1961.
4. Gehl, J. *Life between Buildings: Using Public Space*; The Danish Architectural Press: Copenhagen, Denmark, 1987.
5. Rogers, R. Przedmowa. Preface. In *Miasta są dla Ludzi [Cities are for the People]*; Gehl, J., Ed.; RAM: Kraków, Poland, 2014; Volume IX.
6. Montgomery, J. Making a city: Urbanity, vitality and urban design. *J. Urban Des.* **1998**, *3*, 93–116. [CrossRef]
7. Childs, M.C. *Squares: A Public Place Design Guide for Urbanists*; University of New Mexico: Albuquerque, NM, USA, 2004.
8. Czepczyński, M. Przestrzeń publiczna jako forma reprezentacji społeczności lokalnych. Między hibernacją a animacją centrów małych miast woj. pomorskiego. [Public Space as a Representation of Local Societies. Between Hibernation and Animation of Small Towns Centres of Pomorskie Voivodeship]. In *Przestrzeń Publiczna Małych Miast*; Heffner, K., Marszał, T., Eds.; KPZK PAN: Warsaw, Poland, 2012; Volume 144, pp. 7–19.
9. Carr, S.; Francis, M.; Rivlin, L.G.; Stone, A.M. *Public Space*; Cambridge University Press: Cambridge, UK, 1992.
10. Mandeli, K. Public space and the challenge of urban transformation in cities of emerging economies: Jeddah case study. *Cities* **2019**, *95*, 1–11. [CrossRef]
11. Gehl, J. *Miasta Dla Ludzi [Cities are for the People], tłum. Szymon Nogalski*; RAM: Cracow, Poland, 2014.

12. Zhuang, J. *Creating an Attractive Public Space for the Citizens-Ströget Street in Copenhagen, Demark, Shanxi Road Square in Nanjing, China*; Blekinge Institute of Technology: Karlskrona, Sweden, 2008. Available online: https://www.diva-portal.org/smash/get/diva2:829360/FULLTEXT01.pdf (accessed on 12 September 2021).
13. Wejchert, K. *Przestrzeń wokół nas [The Space Around us]*; Fibak Noma Press: Katowice, Poland, 1993.
14. Walzer, M. Pleasures and Costs of Urbanity. *Dissent* **1986**, *33*, 470–475.
15. Tibbalds, F. *Making People-Friendly Towns: Improving the Public Environment in Towns and Cities*; Harlow: Longman, UK, 1992.
16. Lorens, P. Tematyzacja przestrzeni publicznej jako wyraz dywersyfikacji struktury urbanistycznej miasta doby globalizacji. [Thematisation of Public Space as an Expression of the Diversification of the Urban Structure of the City in the Era of Globalization]. In *Percepcja Współczesnej Przestrzeni Miejskiej*; Madurowicz, M., Ed.; Uniwersytet Warszawski: Warsaw, Poland, 2007; pp. 83–92.
17. Zagroba, M.; Szczepańska, A.; Senetra, A. Analysis and Evaluation of Historical Public Spaces in Small Towns in the Polish Region of Warmia. *Sustainability* **2020**, *12*, 8356. [CrossRef]
18. Jędrzejczyk, D. *Geografia Humanistyczna Miasta [Human Geography of City]*; Wydawnictwo Akademickie Dialog: Warsaw, Poland, 2004.
19. Węcławowicz, G. *Geografia Społeczna Miast. Zróżnicowania Społeczno-Przestrzenne [Social Geography of Cities. Socio-Spatial Differentiation]*; Wydawnictwo Naukowe PWN: Warsaw, Poland, 2007.
20. Jałowiecki, B.; Łukowski, W. *Szata Informacyjna Miasta [The Information Layout of the City]*; Wydawnictwo Naukowe Scholar: Warsaw, Poland, 2008.
21. Maga-Jagielnicka, R. Standardy publicznych przestrzeni miejskich [Standards of Urban Public Space]. In *Przestrzeń Publiczna Małych Miast*; Heffner, K., Marszał, T., Eds.; KPZK PAN: Warsaw, Poland, 2012; Volume 144, pp. 33–46.
22. Carmona, M.; Heath, T.; Oc, T.; Tiesdell, S. *Public Places, Urban Spaces*; Architectural Press: Oxford, UK, 2003.
23. Heffner, K.; Marszał, T. *Przestrzeń Publiczna Małych Miast [Public Space of Small Towns]*; KPZK PAN: Warsaw, Poland, 2012; Volume 144.
24. Litwińska, E. Czy można mówić o specyfice przestrzeni publicznych małego miasta? [Is it possible to talk about the specifics of public spaces in a small towns?]. In *Przestrzeń Publiczna Małych Miast*; Heffner, K., Marszał, T., Eds.; KPZK PAN: Warsaw, Poland, 2012; Volume 144, pp. 21–31.
25. Golędzinowska, A. *Przekształcenia Przestrzeni Publicznej Miasta Średniej Wielkości w Warunkach Gospodarki Rynkowej w Polsce. [Transformations of the Public Space of a Medium-Sized City in the Conditions of the Market Economy in Poland]*; Rozprawa doktorska, Wydział Architektury Politechniki Gdańskiej: Gdańsk, Poland, 2005. Available online: https://pbc.gda.pl/Content/50419/phd_goledzinowska_anna2.pdf (accessed on 24 September 2021).
26. Nowicki, P. Zróżnicowanie przyrynkowej zabudowy i jej funkcji a typy genetyczne rynków w małych miastach województwa łódzkiego. [Diversity of Market Square Buildings and their Functions in the Context of Genetic Types of Market Squares in Small Cities of The Lodz Voivodeship]. *Space Soc. Econ.* **2019**, *30*, 29–49.
27. Ilnicki, D. *Przestrzenne Zróżnicowanie Poziomu Rozwoju Usług w Polsce. Teoretyczne i Praktyczne Uwarunkowania Badań, [Spatial Diversity of Service Development Level in Poland. Theoretical and Practical Determinants of Research]*; Instytut Geografii i Rozwoju Regionalnego, Uniwersytet Wrocławski: Wrocław, Poland, 2009.
28. Gehl, J.; Gemzoe, L. *New City Spaces*, 3rd ed.; The Danish Architectural Press: Copenhagen, Denmark, 2000.
29. Gehl, J. *Cities for People*; Island Press: Washington, DC, USA, 2010.
30. Wojnarowska, A. Przestrzeń publiczna Uniejowa. [Public space of Uniejów]. *Biuletyn Uniejowski* **2015**, *4*, 25–44.
31. Wojnarowska, A. *Jakość Przestrzeni Publicznej Centrum Miasta. Przykład Miast Średnich Regionu Łódzkiego [The Quality of Public Space in the City Center. An Example of Medium-sized Cities in the łódź Region]*; Wyd. Uniwersytetu Łódzkiego: Łódź, Poland, 2017.
32. Bański, J.; Kamińska, W.; Mularczyk, M. The natural and migration movements versus population ageing in Poland's small towns. In *The Routledge Handbook of Small Towns*; Bański, J., Ed.; Routledge: New York, NY, USA, 2021; pp. 138–159.
33. Szczepańska, A.; Pietrzyk, K. An Evaluation of Public Spaces with the Use of Direct and Remote Methods. *Land* **2020**, *9*, 419. [CrossRef]
34. Konecka-Szydłowska, B. Ocena przestrzeni publicznej małych miast aglomeracji poznańskiej. [Assessment of Public Spaces of Small Towns in the Poznań Agglomeration]. *Problemy Rozwoju Miast* **2016**, *3*, 5–12.
35. Kantor-Pietraga, I.; Krzysztofik, R.; Runge, J. Kontekst geograficzny i funkcjonalny kurczenia się małych miast w Polsce południowej. [Geographical and Functional Context of Shrinkage in Case of Small Towns of the Southern Poland]. In *Ewolucja Funkcji małych Miast w Polsce*; Heffner, K., Halama, A., Eds.; Uniwersytet Ekonomiczny w Katowicach: Katowice, Poland, 2012; pp. 9–24.
36. Kamińska, W. *Kapitał Ludzki i Społeczny w Procesie Rozwoju Obszarów Wiejskich w Polsce. Przykład Województwa Świętokrzyskiego. [Human and Social Capital in the Process of Rural Development in Poland. Example of the Świętokrzyskie Voivodeship]*; Wydawnictwo Uniwersytetu Humanistyczno-Przyrodniczego Jana Kochanowskiego w Kielcach: Kielce, Poland, 2011.
37. Cichocki, M. Współczesne przestrzenie publiczne w małych miastach na przykładzie miasta Tłuszcz. [Contemporary Public Spaces of Small Towns on the Example of Tłuszcz]. *Urban Dev. Issues* **2020**, *66*, 197–206. [CrossRef]
38. Zuzańska-Żyśko, E. Koziegłowy–miasto sukcesu gospodarczego. [Koziegłowy—City of the Economic Success]. In *Nowoczesne Instrumenty Polityki Rozwoju Lokalnego—Zastosowanie i Efekty w Małych Miastach*; Heffner, K., Twardzik, M., Eds.; Wydawnictwo Uniwersytetu Ekonomicznego: Katowice, Poland, 2013.

39. Dymek, D.; Jóźwik, J. Kształtowanie placów miejskich na przykładzie miast województwa lubelskiego. [Shaping Town Squares on the Example of the Towns of Lubelskie Voivodeship]. *Ann. Univ. Mariae Curie-Skłodowska Lub. Pol.* **2021**, *76*, 1–28.
40. Boryczka, E. Rewitalizacja miast. [Urban Revitalization]. In *EkoMiasto. Zarządzanie. Zrównoważony, Inteligentny i Partycypacyjny Rozwój Miasta*; Przygodzki, Z., Ed.; Wydawnictwo Uniwersytetu Łódzkiego: Łódź, Poland, 2016; pp. 167–193.
41. Wendt, J. *Przestrzenne Zróżnicowanie i Uwarunkowania Przenikania Systemu Demokratycznego w Polsce i w Rumunii. [Spatial Differentiation and Conditions for the Penetration of the Democratic System in Poland and Romania]*; Carta Blanca: Warsaw, Poland, 2004.
42. Wendt, J. *Wymiar Przestrzenny Struktur i Aktywność Społeczeństwa Obywatelskiego w Polsce [Spatial Dimension of Structures and Activity of the Civil Society in Poland]*; IGiPZ PAN: Warsaw, Poland, 2007.
43. Wysocki, M. *Dostępna Przestrzeń Publiczna. Samorząd Równych Szans [Accessible Public Space. Self-Government of Equal Opportunities]*; Fundacja Instytut Rozwoju Regionalnego: Cracow, Poland, 2009.
44. Heffner, K.; Halama, A. (Eds.) *Ewolucja Funkcji Małych Miast w Polsce [Evolution of the Functions of Small Towns in Poland]*; Studia Ekonomiczne; Zeszyty Wydziałowe Naukowe Uniwersytetu Ekonomicznego w Katowicach: Katowice, Poland, 2012.
45. Kudełko, J.; Zioło, Z. Funkcje małych miast w przestrzeni rolniczej [Functions of Small Towns in the Agricultural Space]. *Studia Obszarów Wiejskich* **2006**, *11*, 39–58.
46. Marszał, T. (Ed.) *Funkcja Przemysłowa Małych Miast [Industrial Function of Small Towns]*; Wydawnictwo Uniwersytetu Łódzkiego: Łódź, Poland, 2009.
47. Nowak, J.; Witeska, M. *Scenariusze Rozwoju Małych Miast [Scenarios for the Development of Small Towns]*; Polski Instytut Ekonomiczny: Warsaw, Poland, 2019.
48. Kamińska, W. Rewitalizacja i zróżnicowanie funkcjonalne przestrzeni publicznej w małych miastach. Przykład rynku w Chęcinach w woj. świętokrzyskim [Revitalization and Functional Diversification of Public Space in Small Towns. An Example of the Square in Chęciny in the Province Świętokrzyskie]. *Studia Śląskie* **2021**, *88*, 27–42.
49. Kamińska, W.; Mularczyk, M. Rynki jako przestrzeń publiczna w nowych małych miastach. Przykład województwa świętokrzyskiego [Squers as Public Space in New Small Towns. An Example of the Świętokrzyskie Voivodeship]. In Proceedings of the 36 Seminarium Geografii Wsi, Olsztyn, Poland, 21–22 June 2021.
50. Brol, R. Procesy urbanizacji wsi polskiej. [The Processes of Urbanization of the Polish Countryside]. In *Prace Naukowe Akademii Ekonomicznej we Wrocławiu. Seria: Monografie i Opracowania*; Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu: Wrocław, Poland, 1996; p. 739.
51. Kamińska, W. *Urbanizacja Obszarów Wiejskich Województwa Świętokrzyskiego [Urbanization of Rural Areas in the Świętokrzyskie Voivodeship]*; Wydawnictwo Uniwersytetu Humanistyczno-Przyrodniczego Jana Kochanowskiego w Kielcach: Kielce, Poland, 2010.
52. Bagiński, E. *Małe Miasta w Strukturze Osiedleńczej Polski [Small Towns in the Settlement Structure of Poland]*; Oficyna Wydawnicza Politechniki Wrocławskiej: Wrocław, Poland, 1988.
53. Saterus, P. *Leksykon Urbanistyki i Planowania Przestrzennego [Lexicon of Town Planning and Spatial Planning]*; BEL Studio: Warsaw, Poland, 2013.
54. Sokołowski, D. Urbanizacja wsi na przykładzie miast zdegradowanych województwa świętokrzyskiego. [Urbanization of Villages on the Example of Former Towns in the *Świętokrzyskie* Voivodeship]. *Studia Obszarów Wiejskich* **2015**, *37*, 195–216. [CrossRef]
55. Mularczyk, M. *Regionalny System Miast—Hierarchia czy Poziomy Układ Sieciowy? Przykład Województwa Świętokrzyskiego [Regional System of Cities—Hierarchy or Horizontal Network System? An Example of the Świętokrzyskie Voivodeship]*; Wydawnictwo Uniwersytetu Jana Kochanowskiego: Kielce, Poland, 2016.
56. Kot, R. The Point Bonitation Method for Evaluating Geodiversity: A Guide with Examples (Polish Lowland). *Geografiska Annaler Ser. A Phys. Geogr.* **2015**, *97*, 375–393. [CrossRef]
57. Mueller, L.; Schindler, U.; Mirschel, W.; Shepherd, T.G.; Ball, B.C.; Helming, K.; Rogasik, J.; Eulenstein, F.; Wiggering, H. Assessing the Productivity Function of Soils. *Agron. Sustain. Dev.* **2010**, *30*, 601–614. [CrossRef]
58. Bastian, O.; Meyer, B.C.; Panse, E.; Röder, M.; Syrbe, R.-U. Landscape Assessment. In *Development and Perspectives of Landscape Ecology*; Bastian, O., Steinhardt, U., Eds.; Kluwer: Dordrecht, The Netherlands, 2002; pp. 205–255.
59. Rucińska, D.; Zagrzejewska, M. The Point Bonitation Method and its Adaptation in Risk Studies: A Case Study in Sri Lanka's Cities in the Coastal Zone. *Int. J. Environ. Res. Public Health* **2021**, *18*, 2060. [CrossRef] [PubMed]
60. Reynard, E.; Fontana, G.; Kozlik, L.; Scapozza, C. A Method for Assessing 'Scientific' and 'Additional Values' of Geomorphosites. *Geogr. Helvatica* **2007**, *62*, 148–158. [CrossRef]
61. Kowalska, K. An Attempt at an Integrated Assessment of the Tourism Attractiveness of a Region: The Example of North Karelia (Finland). *Tourism* **2012**, *22*, 21–28. [CrossRef]
62. Richling, A.; Solon, J. *Ekologia Krajobrazu [Landscape Ecology]*; PWN: Warsaw, Poland, 2011.
63. Okros, A.; Mihut, C.; Niță, L.D. Yield Capacity of the Soils in Recas, Viticulture Centre, Timis Country. *Res. J. Agric. Sci.* **2012**, *44*, 95–101.
64. Musielok, Ł.; Drewnik, M.; Stolarczyk, M.; Gus, M.; Bartkowiak, S.; Kożyczkowski, K.; Lasota, J.; Motak, A.; Szczechowska, K.; Wątły, M. Rates of Anthropogenic Transformation of Soils in the Botanical Garden of Jagiellonian University in Kraków (Poland). *Catena* **2018**, *170*, 272–282. [CrossRef]

65. Koźma, J. Metodyka waloryzacji przestrzennej pokrycia terenu i obiektów ochrony przyrody na potrzeby oceny konfliktowości potencjalnej eksploatacji kopalin w obszarach perspektywicznych [Methodology of Spatial Valorization of Land Cover and Objects of Nature Conservation in Assessment of Potential Conflict of Exploitation of Minerals in Prospective Areas]. *Przegląd Geologiczny* **2015**, *63*, 581–588.
66. Fassoulas, C.; Mouriki, D.; Dimitriou-Nikolakis, P.; Iliopoulos, G. Quantitative Assessment of Geotopes as an Effective Tool for Geoheritage Management. *Geoheritage* **2012**, *4*, 177–193. [CrossRef]
67. Martínez-Graña, A.M.; Goy, J.L.; Cimarra, C.A. A Virtual Tour of Geological Heritage: Valourising Geodiversity Using Google Earth and R Code. *Comput. Geosci.* **2013**, *61*, 83–93. [CrossRef]
68. Rocha, J.; Brilha, J.; Henriques, M.H. Assessment of the Geological Heritage of Cape Mondego Natural Monument (Central Portugal). *Proc. Geol. Assoc.* **2014**, *125*, 107–113. [CrossRef]
69. Zwoliński, Z.; Najwer, A.; Giardino, M. Methods for Assessing Geodiversity. In *Geoheritage. Assessment, Protection, and Management*; Reynard, E., Brilha, J., Eds.; Elsevier: Chennai, India, 2018; pp. 27–52.
70. Turel, H.S.; Yigit, E.M.; Altug, I. Evaluation of Elderly People's Requirements in Public Open Spaces: A Case Study in Bornova District (Izmir, Turkey). *Build. Environ.* **2007**, *42*, 2035–2045. [CrossRef]
71. Perovic, S.; Kurtovic Folic, N. Visual Perception of Public Open Spaces in Niksic. *Procedia Soc. Behav. Sci.* **2012**, *68*, 921–933. [CrossRef]
72. Micek, M.; Staszewska, S. Urban and Rural Public Spaces: Development Issues and Qualitative Assessment. *Bull. Geogr. Socio-Econ. Ser.* **2019**, *45*, 75–93. [CrossRef]
73. Kucina, W. Projekt Waloryzacji Terenu Nadleśnictwa pod Kątem Turystycznej Atrakcyjności Środowiska [Project of Valorization of the Area of Forest District in Terms of Tourist Attractiveness of the Environment]. Ośrodek Rozwojowo-Wdrożeniowy Lasów Państwowych w Bedoniu; 2006. Available online: www.bedon.lasy.gov.pl/orwlp/turystyka/Prace_naukowe (accessed on 12 September 2021).
74. Rutkiewicz, A.; Stolarski, G.; Sot, H. Turystyczna atrakcyjność nadleśnictwa—Studium przypadku. [Tourist Attractiveness of a Forest District—A Case Study]. *Studia i Materiały CEPL w Rogowie* **2015**, *17*, 187–193.
75. *Ustawa o Planowaniu Przestrzennym* z 27 marca 2003 [The Act on Spatial Planning]. Dz. U. nr 80, poz. 717. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20030800717 (accessed on 28 November 2021).
76. Wejchert, K. *Miasteczka Polskie Jako Zagadnienie Urbanistyczne [Polish Towns as an Urban Issue]*; Zakład Architektury Polskiej i Historii Sztuki Politechniki Warszawskiej: Warsaw, Poland, 1947.
77. Kosiński, W. *Miasto i Piękno Miasta [The City and the Beauty of the City]*; Politechnika Krakowska: Cracow, Poland, 2011.
78. Podciborski, T.; Jędrzejewska, K. Ocena stanu ładu przestrzennego terenów zabudowy wsi warmińskiej. [Assessment of the Status of the Spatial Order of Built-Up Areas in Villages in Warmia]. *Acta Sci. Polonorum. Adm. Locorum* **2011**, *10*, 63–79.
79. Górczyńska, M. Wskaźniki zagospodarowania i ładu przestrzennego w miastach i na obszarach silnie zurbanizowanych, [Indicators for the Assessment of Spatial Organization and Spatial Order in Cities and in Urbanized Areas]. *Biuletyn KPZK PAN* **2013**, *252*, 87–109.
80. Maliszowa, B. *Śródmieście. Wybrane Zagadnienia Planowania [Downtown. Selected Planning Issues]*; Arkady: Warsaw, Poland, 1974.
81. Springer, F. *Wanna z Kolumnadą. Reportaże o Polskiej Przestrzeni [Colonnaded Bathtub. Reportages about Polish Space]*; Wyd. Czarne: Wołowiec, Poland, 2013.
82. *Ustawa Prawo budowlane* z 7 lipca 1994 [Construction Act]. Dz.U. nr 89, poz. 1333. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU19940890414 (accessed on 28 November 2021).
83. Jałowiecki, B.; Szczepański, M. *Miasto i Przestrzeń w Perspektywie Socjologicznej [City and Space in a Sociological Perspective]*; Wydawnictwo Naukowe Scholar: Warsaw, Poland, 2006.
84. *Encyklopedia Powszechna [Universal Encyclopedia]*; Wydawnictwo Naukowe PWN: Warsaw, Poland, 2009.
85. Eco, U. *History of Beauty*; Rizzoli International Publications: New York, NY, USA, 2005.
86. Bierwiaczonek, K. *Społeczne Znaczenie Miejskich Przestrzeni Publicznych [Social Importance of Urban Public Spaces]*; Wyd. Uniwersytetu Śląskiego: Katowice, Poland, 2016.
87. Zipser, T. *Zasady Planowania Przestrzennego [Principles of Spatial Planning]*; Politechnika Wrocławska: Wroclaw, Poland, 1983.
88. Szczepański, M.S. *Miasto Socjalistyczne i Świat Społeczny Jego Mieszkańców [A Socialist City and the Social World of Its Inhabitants]*; Europejski Instytut Rozwoju Lokalnego i Regionalnego: Warsaw, Poland, 1991.
89. Lattman, P. The Origins of Justice Stewart's "I Know It When I See It". LawBlog at The Wall Street Journal Online. *Wall Street Journal*. 27 September 2007. Available online: https://www.wsj.com/articles/BL-LB-4558 (accessed on 3 November 2021).
90. Gołaszewska, M. *Zarys Estetyki. [Outline of Aesthetics]*; PWN: Warsaw, Poland, 1984.
91. Groeger, L. Przestrzeń publiczna małego miasta w opinii mieszkańców (Przykład Łasku) [Public Space of a Small Town in the Opinion of the Inhabitants (Example of Łask)]. In *Przestrzeń Publiczna Małych Miast*; Heffner, T., Marszał, T., Eds.; KPZK PAN: Warsaw, Poland, 2012; Volume 144, pp. 123–134.
92. Poradnik o Przestrzeniach Publicznych. Studium Ogólnomiejskich Przestrzeni Publicznych [A Guidebook on Public Spaces. Study of City-Wide Public Spaces]. Gdańsk. 2014. Available online: https://www.brg.gda.pl/planowanie-przestrzenne/inne-opracowania-urbanistyczne/62-sopp-studium-ogolnomiejskich-przestrzeni-publicznych (accessed on 10 September 2021).

93. Łaguna, D. Przekształcenia przestrzeni publicznej w miastach położonych na szlaku Wielkich Jezior Mazurskich. [Transformations of the Public Space in Towns Located on the Route of the Great Masurian Lakes]. In *Przestrzeń Publiczna Małych Miast*; Heffner, K., Marszał, T., Eds.; Studia KPZK PAN: Warsaw, Poland, 2012; Volume 144, pp. 81–98.
94. Kozłowski, S.; Borowska, M. Rewitalizacja historycznego centrum Łęczycy, [Revitalization of the Historic Center of Łęczyca]. In *Przestrzeń Publiczna Małych Miast*; Heffner, K., Marszał, T., Eds.; Studia KPZK PAN: Warsaw, Poland, 2012; Volume 144, pp. 111–122.
95. Lorens, P. Porządek architektoniczny i urbanistyczny jako element przestrzennego zagospodarowania kraju. [Architectural and urban order as an element of spatial development of the country]. *Studia Regionalne i Lokalne* **2005**, *6*, 21–50.
96. Holland, C.; Clark, A.; Katz, J.; Peace, S. *Social Interactions in Urban Public Places*; Bristol University Press: Bristol, UK, 2007.
97. Whyte, W.H. *The Social Life of Small Urban Spaces*; Conservation Foundation: Washington, DC, USA, 1980.
98. *Ustawa o Drogach Publicznych* z 21 marca 1985 [Public Roads Act]. Dz. U. nr 14, poz. 60. Available online: http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu19850140060 (accessed on 28 November 2021).
99. Trancik, R. *Findings Lost Spaces: Theories of Urban Design*; Van Nostrand Reinhold: New York, NY, USA, 1986.
100. Oktay, D. The Quest for Urban Identity in the Changing Context of the City: Northern Cyprus. *Cities* **2002**, *19*, 31–41. [CrossRef]
101. Wilczyński, R. Przestrzeń wiejska [Rural Space]. In *Przestrzeń życia Polaków*; Stowarzyszenie Architektów Polskich SARP: Warsaw, Poland, 2014; pp. 37–64.
102. Watson, D.; Plattus, A.; Shibley, R. (Eds.) *Time-Saver Standards for Urban Design*; The McGraw-Hill Companies: New York, NY, USA, 2003.

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Regional Spatial Approach to Differences in Rural Economic Development: Insights from Serbia

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Abstract: Rural regions with a larger share of the primary sector in the overall economy are limited in their ability to achieve a sufficient level of competitiveness. In countries such as Serbia, where rural areas play an important role, addressing the problems affecting these areas is important for overall development. The purpose of this study is to determine the socioeconomic performance of the rural regions of Serbia and the EU in order to indicate the position of Serbia's rural areas in the process of European integration. NUTS 3 (NUTS 2 for Germany) was used for analysis, and from this an Index of Socioeconomic Performance was created. This Index was created using Factor Analysis. The results point to Serbia lagging behind other EU regions in terms of development, with most of Serbia's rural regions receiving the lowest ratings. These results are cause for alarm and indicate a need to create strategies that will direct resources towards key issues in these areas, whose potential would be adequately used through the implementation of rural policy measures, with the aim of overall socioeconomic development.

Keywords: rural; factor analysis; underdeveloped regions; European integration; Serbia

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1. Introduction

Depending on the methodology applied, rural areas comprise about 80% of land in Serbia, and contain between 40% and 50% of the population, which indicates the specific relevance of these areas for the overall Serbian economy. The development of local infrastructure and basic services in rural areas, including leisure and culture services, the renewal of villages and activities aimed at the restoration and upgrading of the cultural and natural heritage of villages is an essential element for the socioeconomic development of rural areas [1]. Rural regions are mainly based on sectors that use natural resources such as agriculture, forestry, fishing, oil, gas, and electricity. Therefore, competitiveness of the primary sector remains the policy focus for developing these areas. In more developed countries, tourism and services, or renewable energy production are associated sectors that also rely on natural resources and make significant contributions to the socioeconomic development of rural areas. The strength of the link between agriculture and other sectors is influenced by various factors such as the natural characteristics of the terrain (land quality, climate, and local tourist attractions), infrastructure, the overall strength of the national economy, the educational level and entrepreneurial potential among the local population, and access to public finances [2]. Namely, in rural areas with demographic problems, rural tourism could be an additional activity that could make the traditional agricultural function of those places secondary, so it could change those areas into multifunctional spaces [3]. Rural areas are usually poorer and less populated than urban areas. Berc et al. [4] indicate that in rural areas poor availability of certain social services is often accompanied by weak coordination of service providers within the social welfare system, which speaks in favour of the present difficulties in the implementation of deinstitutionalization and decentralization of social services.

The income disparities between rural and urban areas in Serbia have deepened with the process of transforming a centrally planned economy into a market-oriented economy. Following a dynamic transition process, a clear strategic goal for Serbia is integration into the European Union (EU), which requires additional economic and institutional changes. The dynamics of European integration differ among the formerly communist and socialist countries. For Serbia, which is currently a candidate country for EU membership, the experience in pre-accession negotiations of New Member States (NMS), i.e., Central and Eastern Europe (CEE) are a valuable benchmark for future integration processes. Böwer and Turrini [5] investigated the effects of EU accession on NMS, and they concluded that this region has widely benefited from economic and institutional integration with the EU. The socioeconomic growth recorded in NMS after the recovery from transition shock in the early 1990s has been impressive.

The study presented in this paper focuses on Serbia's rural areas, as well as future development strategies for these areas, in order to better prepare them for EU integration. The agricultural sector has a significant position in the overall Serbian economy and even more so in the rural areas, where it is often the dominant activity for most of the population [6]. Based on agri-environmental conditions, the rural areas of Serbia can be divided into two regions: northern and southern. The northern region has exceptional agri-environmental conditions for agricultural development and a high concentration of food industry [7]. The southern part of Serbia is characterized by mountainous areas with relatively poorer conditions for agricultural production. In addition, both regions are characterized by an unfavourable demographic structure with a very low level of education of the rural population. According to Petrović et al. [8], modest knowledge and the absence of supplementary skills in the rural population are limitations for the total capacity and competitiveness of the labour force in rural areas, which can be anticipated as one of the burdening factors in the economic development of these areas.

Creating an appropriate rural policy in Serbia within the conditions of current European integration requires harmonization with the EU's Common Agricultural Policy (CAP), which is one of Serbia's future priorities. The CAP represents the benchmark for future policy, so pressures of the EU accession negotiations, as well as EU pre-accession support will be the key elements in the process of adapting policies to the CAP [9]. However, harmonization of legislation, institutional capacity building, and policy reform in agriculture and rural development are complex issues. Therefore, economic, social, political, and environmental conditions must be taken into account when defining political measures and instruments. Namely, as space and land are limited resources, an era of rapid urbanization should be effectively controlled in line with sustainable development principles [10]. The principles of sustainable development integrate political, economic, and social measures in order to meet the needs of communities without compromising the ability of future generations to meet their needs [11].

The European Union offers various opportunities for receiving financial support, which allows the exchange of best practices whereby the benefit is realized by Serbia, and even certain regions that have adequate cooperation with EU countries, such as Vojvodina [12]. The European Commission [13] estimated that good progress was made by adopting the action plan for acquis alignment in agriculture and rural development and implementing the Instrument for Pre-accession Assistance for Rural Development program (IPARD II). Although it is very important to access these funds, primarily because of the relative significance of agriculture for the overall economy as well as Serbia's rural areas, it must also be emphasized that pre-accession assistance does not solve the key development problems of rural areas, which require a comprehensive, long-term, territorial-based national policy that respects local specificities and the needs of the rural population [14]. Sustainable development of agriculture entails sustained economic growth, technological advancement, efficient resource management, and an increase in quality of life in rural areas [15].

In order to monitor and compare the socioeconomic conditions of different heterogeneous territories across EU countries, the Nomenclature of Statistical Territorial Units (NUTS) was adopted by the EU. The NUTS classification is a framework for determining standardized statistics of all EU Member States at three basic levels: NUTS 1 (population of 3 to 7 million), NUTS 2 (population of 800,000 to 3 million) and NUTS 3 (population of 150,000 to 800,000) [16]. The Nomenclature of Statistical Territorial Units has also been defined for EU candidate countries (Serbia, North Macedonia, Albania, Montenegro, and Turkey), which allows for comparison of regions or districts across Europe. In Serbia, this classification is the basis used to draft documents needed to implement projects that should be financed by the European Union's structural funds [17].

The study presented here is designed to help candidates for membership determine the position of their regions vis-à-vis EU regions and as such can be applied to other candidate countries in addition to Serbia: Montenegro, Albania, North Macedonia, and Turkey. Moreover, this study will be a step forward in comparison with the existing literature, given the minimal amount of research conducted at the regional level in Serbia. The results provide an empirical basis for creating future rural development strategies for Serbia by giving a detailed insight into socioeconomic performance at the regional level, and enabling a comparative analysis with EU countries as well as with regions within Serbia itself. The methodology adopted in this way, and when applied to other candidate countries, would provide an overview of socioeconomic performance across Europe. Identifying a candidate country's level of development in relation to the Member States is important for the harmonization of policies, such as Serbia's rural policy and the EU CAP or regional policies. This indicates the practical contribution this study can provide. The purpose of this study is to determine the socioeconomic performance of rural regions of Serbia and the EU in order to indicate the position of Serbia's rural areas in the process of European integration. More specifically, the aim is to detail the socioeconomic performance of rural regions, which will be evaluated with an Index of Socioeconomic Performance evaluated by Factor Analysis (FA).

Based on the purpose of this paper, the main hypothesis of the research is created:

- *The socioeconomic performance of Serbian rural regions corresponds to the socioeconomic performance of rural regions of NMS.*

2. Theoretical Background

Regional development plays a significant role in the EU. The regional aspect has been given more importance in the EU, primarily through the Cohesion policy, i.e., strengthening the economic, social, and territorial cohesion within the EU. One of the EU's key objectives is to reduce development inequalities between developed and economically underdeveloped regions. EU enlargement to the south, and especially to the east, has been followed by growing inequalities within the Union. The more developed, pre-2004 member states (EU-15) channelled financial resources through the Cohesion policy to less developed NMS to support transformation and economic convergence [18]. The EU Cohesion policy does not include only economic convergence, but it is certainly still the most important objective of this policy due to large income discrepancies. In recognizing a need to assess more place-sensitive policies, highlighting heterogeneity generally contributes to the debate on the future of the post-2020 Cohesion Policy, by providing effective comparative tools to support new policy instruments [19]. In addition to this policy, others, namely the EU rural development policy, have had significant impacts on the regional development of the EU as a whole [20].

The EU Cohesion policy plays an important role in supporting the socioeconomic development of rural areas and, together with the European Agricultural Fund for Rural Development (EAFRD), involves directing financial resources towards the reconstructing and revitalizing these areas. EAFRD is part of the EU's CAP, but with a regional focus [21]. Matthews [22] states that one of the general objectives of the CAP for rural development in the upcoming period (2021–2027) is to "strengthen socio-economic performance in rural areas" through specific objectives such as attracting and retaining young farmers in rural areas; promoting employment, social inclusion and local development through increased bioenergy production and sustainable forestry; an adequate response to the increased demand for health-safe foods; and the use of innovation and digitalization for both agriculture and rural areas. Increased demand for renewable energy can be a good development opportunity for rural areas. Vukadinović and Ješić [23] point out that creating "green jobs" through the concept of a circular economy is important for employment growth, given that economic growth is becoming an effective use of resources and renewable energy resources, as well as the use of comparative advantages of the natural environment. However, the heterogeneity of rural areas or regions significantly impedes the convergence process. The objectives of rural policy have become multidimensional and focus on increasing the wellbeing of rural residents. Generally speaking, quality of life has several dimensions: (1) an economic dimension, in which the income of the population depends on being able to find employment in companies that are productive and competitive; (2) the social dimension, which refers to accessibility to services; and (3) a local dimension, which refers to the environment [2]. Although it is necessary examine rural areas according to several aspects, the socioeconomic aspect is always an important link to future development. The European development model is characterized by balancing economic and social performance, and quality of life, as a top European priority [24]. In most of the rural typologies, the structure of employment by sectors was analysed in order to define the role and significance of agriculture and other sectors within the rural area. Moreover, the importance of the sector is determined by their share in the Gross Value Added (GVA) of the region. The employment structure is also important for the region's socioeconomic development. The traditional approach to identifying regional competitiveness is based on an analysis of GDP per capita [25]. Michalek and Zarnekow [26] pointed to the use of GDP per capita (calculated at NUTS-2 or NUTS-3 level) as: (a) a standard measure of a regional level of welfare; (b) a basic criterion of eligibility criteria for EU funding under structural funds, and (c) the main quantitative indicator of the effectiveness of the policies being pursued. Moreover, Prus et al. [27] have used a significantly larger number of variables to determine the socioeconomic characteristics of certain regions.

Domazet et al. [28] indicate the importance of following up macrocompetitiveness of the EU, or countries around the world by the European Commission in its European Competitiveness Report, which examines the basic performance of the competitiveness of the EU as a whole, member states, or certain economic activities, while the WEF (World Economic Forum) affirmed the GCI Index (Global Competitiveness Index) for following up basic indicators of the competitiveness of countries around the world. Regional competitiveness is the ability of a region to offer an environment attractive and sustainable for businesses and in which residents can live and work [29]. As noted, each round of EU enlargement deepened regional differences. Here, the focus will be on the EU enlargement of 2004, since expansion from that period on included countries with the same historical legacy of centrally planned economies as Serbia (with the exception of two island countries, Cyprus and Malta). The countries of Central Europe, and Eastern Europe in particular, are considered to be less economically developed regions in comparison to the original EU member states (for example Benelux, Germany, and France) due to the strategy of socialism, i.e., industrialization which led to economic, social, and environmental decline. Accordingly, to better facilitate accession for the CEE countries, two EU programs were launched at the end of the 1990s, which strongly shaped the regional policies of the CEE countries: the Instrument for Structural Policies for Pre-Accession (ISPA) and the Special Accession Program for Agriculture and Rural Development (SAPARD), in order to prepare future members for Cohesion Policy (first fund) and for the EU CAP (second fund) [30]. Bachtler and Ferry [31] point to the importance of using these funds when CEE countries join the EU, as well as to different strategies in spending structural funds in these countries, which have further affected regional inequalities.

Rural development largely depends not only on national policies (rural, regional, social, etc.) but also on factors that influence heterogeneity, with future development based on addressing specific problems affecting a particular territory [32]. The development of regions, or the convergence of less developed, usually rural regions with developed regions, creates a need to territorialize and regionalize development policies, while also seeking competitive advantages for localities [33]. Resolving the issue of rural development necessitates an integrated approach that requires cross-sectoral cooperation at all levels (national, regional, and local). Issues related to rural policy in Serbia are reflected not only in the low level of funds allocated for rural development but also in the defined measures, which are directed more towards investing in agricultural production itself rather than in the development of infrastructure in rural areas, the environment, or improving quality of life in rural areas [34]. Limited human resources, lack of regulatory framework and funding, and insufficient experience in both policy formulation and major project management are the main obstacles to effective rural development policies in Serbia, the most important task of which should be strengthening local self-government capacity [35]. In the EU, the LEADER (an acronym for the French Liaison Entre Actions de Développement de l'Economie Rurale) program supports capacity-building of local authorities and the development of local partnerships, and emphasizes the importance of rural development projects launched at the local level to revitalize rural localities [36]. The involvement of Local Action Groups (LAGs) in the decision-making and priority-setting process for local territorial development, i.e., a bottomup approach, is a significant segment of EU rural development policy. However, the process of regionalization and decentralization in Serbia is insufficient; the distribution of responsibilities is asymmetric at different territorial levels, which will be unsustainable in the future. Although today we are in the Fourth Industrial Revolution with significant social transformation in parallel with technological change [37], rural areas lag significantly behind urban areas, with limited access to technology, information, and new knowledge.

3. Materials and Methods

In this research, the methods of multivariate statistical analysis were used, i.e., Factor Analysis, which aims to reduce large numbers of variables to a more manageable number while discarding a minimum amount of useful information. The advantage of FA is that it enables researchers to take an important step towards deeper understanding of a complex and multidimensional territory such as, in this case, rural areas [38]. Moreover, the advantage of using factorial techniques is that no prejudgment of the results is required, as the technique itself determines the importance of individual factors (dimensions) within any solution derived from it [39]. The conditions required for the FA to be applied were checked by Bartlett's test and by Kaiser–Meyer–Olkin (KMO) sampling adequacy testing [40]. The KMO value is a measure of adequacy of the correlation matrix to perform the FA. The KMO test ranges from 0.0 to 1.0, but values should be greater than 0.5.

Factor loadings represent the correlation between the original variables and the factors and are key to understanding the nature of a particular factor. When using practical significance as the criteria, Hair et al. [40] suggested that factor loadings in range ± 0.50 or greater are considered practically significant. Interpretation of factors, based on factor loadings, is an important step. If it is necessary, factor rotation should be performed. The goal of VARIMAX rotation is to maximize the variance of factor loadings by making high loadings higher and low ones lower for each factor [41]. After factor extraction, it is necessary to calculate the factor scores for each unit of observation for each factor. Factor scores are standardized to have a mean of 0 and a standard deviation of 1. Factor score calculations enable creation of an index for each factor so that observation units can be ranked. There are also some limitations and disadvantages of the method used in this analysis. For example, Cloke and Edwards [42] admit that multivariate classification techniques in general are subject to considerable methodological disagreement and that the validity of individual classifications rest on their usefulness far more than on their methodological basis.

More systematically, this research will follow certain statistical assumptions and procedures when conducting FA:

- A defined research problem indicates the use of research FA;
- R type factor analysis;
- Data standardization by Z-transformation;
- Bartlett's test and the Kaiser–Meyer–Olkin test (KMO) (>0.6);
- Correlation matrix (at least 0.3 or higher Pearson correlation coefficient);
- Analysis of the Principal Components as a method of factor extraction;
- Kaiser's criterion to determine the number of factors (eigenvalue greater than 1);
- VARIMAX factor rotation with Kaiser normalization;
- Accepted factor loads in the range greater than ±0.50, and
- Calculated factor scores for all observation units, for all factors.

In this analysis, NUTS 3 were selected as the observation units for both the EU countries (with the exception of Germany, for which NUTS 2 were used) and Serbia. Despite criticism, for example, Hedlund [43] pointed to need for typologies based on high-resolution data, beyond the urban–rural continuum, respectively the administrative boundary, this level was chosen for two reasons. First, it represented the lowest administrative and territorial level at which data could be found for all countries included in the analysis; second, regional typologies applied at this level aimed to analyse and monitor rural and urban development by implementing certain regional and rural policies and programs. NUTS 3 allowed a detailed representation of EU rural space [44]. It is worth noting that the degree of differentiation among European rural regions is in line with the transitional processes described in the literature [45], which is especially significant for former socialist states, both in the EU and in those, such as Serbia, which are candidates for membership. Spatial (i.e., territorial) distribution of regional performance was considered: different components followed different territorial paths across Europe, suggesting the existence of a puzzled core–periphery pattern, where within-region differences also matter [46].

Since this study focuses on rural regions, predominantly urban regions were excluded as defined by Tercet (Regulation (EU) 2017/2391) [47], i.e., the EU's Urban–rural typology, because they have urban centres with over 500,000 inhabitants, and they contain at least 25% of these regions' populations. Instead, the focus was primarily on predominantly rural and intermediate regions. These two groups of areas were defined as "non-urban" areas [48]. Certain limitations to this approach should also be noted. Primarily, intermediate regions were of particular concern, since they have a wide range of different spatial characteristics. However, the inclusion of intermediate regions in the analysis was justified by the need to consider as large a geographical area as possible, as well as by the need to include most of Serbia in the analysis, which, according to the Urban–rural classification of the EU, was designated as a state with one predominantly urban region (Belgrade District), five predominantly rural regions, and 19 intermediate regions. A total of 691 units were included in the analysis, of which 667 were at NUTS 3 and 24 at NUTS 2. Certain areas, although classified as intermediate or predominantly rural, were excluded from the analysis due to lack of data (primarily for the newly created NUTS 3 areas), or due being located geographically outside of the European continent.

The Eurostat database [49–51] was used for this study, and the time period was a seven-year average from 2012 to 2018, with some exceptions for France and Poland (three-year average from 2014 to 2016). The analysed period also coincided with the period of candidacy for Serbia's EU membership (from 2012 to the most recent data available). The observation units in this paper were all EU countries and Serbia. The Statistical Package for the Social Sciences program-SPSS Statistics 20.0 was used for the purposes of this paper. Variables used to create the regional Index of Socioeconomic Performances, using FA, were: share of employees in the primary sector in the total number of employees (%) (EMPL_PRIMARY); gross domestic product (GDP) per capita (purchasing power standard-PPS) (GDP_PER_CAPITA); primary sector share in total gross value added (GVA) (%) (GVA_PRIMARY); total labour productivity (total GVA of all activities per employee) (EUR/person) (LABOUR_TOTAL); and labour productivity in the primary sector (GVA of the primary sector per employee in the primary sector) (EUR/person) (LABOUR_PRIMARY). The selection of variables was determined by the availability of data in the database used. Bearing in mind that Serbia is a candidate country for EU membership, the choice of data in the Eurostat database is scarce. Additionally, according to previous research, the selected variables well describe the socioeconomic performance of rural areas, which is the main subject of this analysis.

4. Results

This study began with the selection of variables with an emphasis on the vital sector of rural areas. The results of the KMO test as a measure of sample adequacy (0.730) were moderately good according to the Kaiser classification. In addition, Bartlett's test of sphericity was statistically significant (Table 1). The results of these two tests indicated the adequacy of the use of Factor Analysis in this study. Subsequently, a Correlation Analysis was performed, followed by a Factor Analysis.

Table 1. KMO and Bartlett's Test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.730
Bartlett's Test of Sphericity	Approx. Chi-Square	2720.081
	df	10
	Sig.	0.000

Source: the authors' calculations.

This factor explained 71.511% of total variance, with eigenvalues higher than 1 (3.576) (Table 2). The correlation matrix indicated that GDP per capita was positively correlated with labour productivity (total economy and primary sector), while it was negatively correlated with the share of employees in the primary sector as well as the share of the primary sector in total GVA (Table 2), thus indicating that high dependence on the primary sector is a feature of regions that are in a less favourable economic situation and are thus less competitive regions. Factor loadings for this dimension are also presented in Table 2. The positive sign in front of the factor loadings of the variables GDP per capita, total labour productivity of all sectors, and labour productivity in the primary sector indicate overall socioeconomic development in the region, while the negative sign in front of the factor loadings of the variables share of employees in the primary sector as well as the share of the primary sector in the creation of GVA indicate that the primary sector is of less importance in more economically developed regions. The dominant variable within this factor, and with the highest correlation with the factor, was the GDP per capita (0.872). The calculated factor scores for this factor indicated the level of economic development, or wellbeing, across regions in the EU and Serbia, with the best rated observation units showing the best socioeconomic performance.

Factor scores, i.e., Index of Socioeconomic Performance, were ranked within a range of −3 to 3 and divided into quintiles. The averages for the five groups identified in Table 3 were drawn according to the level of socioeconomic development. Group 1, which included most of the intermediate and predominantly rural regions in Serbia, had an average of 27.6% of employees working in the primary sector; the primary sector had an 11.2% share of GVA creation, and the lowest levels of GDP per capita, and labour productivity both in total and in the primary sector. These results are disturbing and point to the great importance of the primary sector in the overall regional economies of NUTS 3 regions. The share of the primary sector in employment and GVA of the region declines and GDP per capita and labour productivity increases were highest in Group 1 and then decline for each subsequent group. In Group 5, the average share of employment in the primary sector was 3% and the average share of GVA was 2%, which indicates other sectors contribute much more to the economy. There has been a decline in the share of employees in agriculture in the EU-15 since 1990, with an average reduction of 2–3% per year, which has resulted in an absolute reduction in the agricultural workforce by about 340,000 workers, or 190,000 annual work units (AWU) [52]. According to the same source, the only exceptions in the EU-15 that do not show a declining trend in the agricultural workforce are in those regions with a high proportion of part-time workers and a larger share of farms engaged in other profitable activities.

Table 2. Results of Factor Analysis: Socioeconomic performance of intermediate and predominantly rural regions.

Correlation Matrix					
	Empl_primary	GDP per capita	GVA_primary	Labour_total	Labour_primary
Empl_primary	1.000	−0.635	0.742	−0.675	−0.603
GDP_per_capita	−0.635	1.000	−6.14	0.847	0.611
GVA_primary	0.742	−0.614	1.000	−0.593	−0.316
Labour_total	−0.675	0.847	−0.593	1.000	0.764
Labour _primary	−0.603	0.611	−0.316	0.764	1.000
Sig. (1-tailed)					
Empl_primary		0.000	0.000	0.000	0.000
GDP_per_capita	0.000		0.000	0.000	0.000
GVA_primary	0.000	0.000		0.000	0.000
Labour_total	0.000	0.000	0.000		0.000
Labour_primary	0.000	0.000	0.000	0.000	
Variance Explained					
			Eigenvalues		
Component	Total	% of Variance		Cumulative %	
1	3.576	71.511		71.511	
Factor Analysis					
			Factor loadings		
Empl_primary			−0.819		
GDP per capita			0.872		
GVA_primary			−0.788		
Labour_total			0.861		
Labour_primary			0.692		

Factor extraction method: Principal Components Analysis. Source: the authors' calculations.

Table 3. Group average.

	Empl_Primary	**GDP_Per_Capita**	**GVA_Primary**	**Labour_Total**	**Labour_Primary**
Group 1	27.58795	11,086.29227	11.24873	15,408.37	8126.198
Group 2	12.93303	16,639.61631	5.829002	29,293.47	16,186.62
Group 3	7.685439	20,311.40772	3.884153	46,029.36	27,705.58
Group 4	4.879643	25,531.23977	2.953308	59,381.36	37,400.79
Group 5	2.954538	31,519.9294	2.030506	66,572.24	45,255.65

Source: the authors' calculations.

In Figure 1, the darkest colour indicates the group with the best socioeconomic performance, and the group with the lowest socioeconomic performance is marked with the lightest colour. Regional inequalities are noticeable both among different countries and within one country. In this study, the focus was on several significant regional inequalities within the observation units.

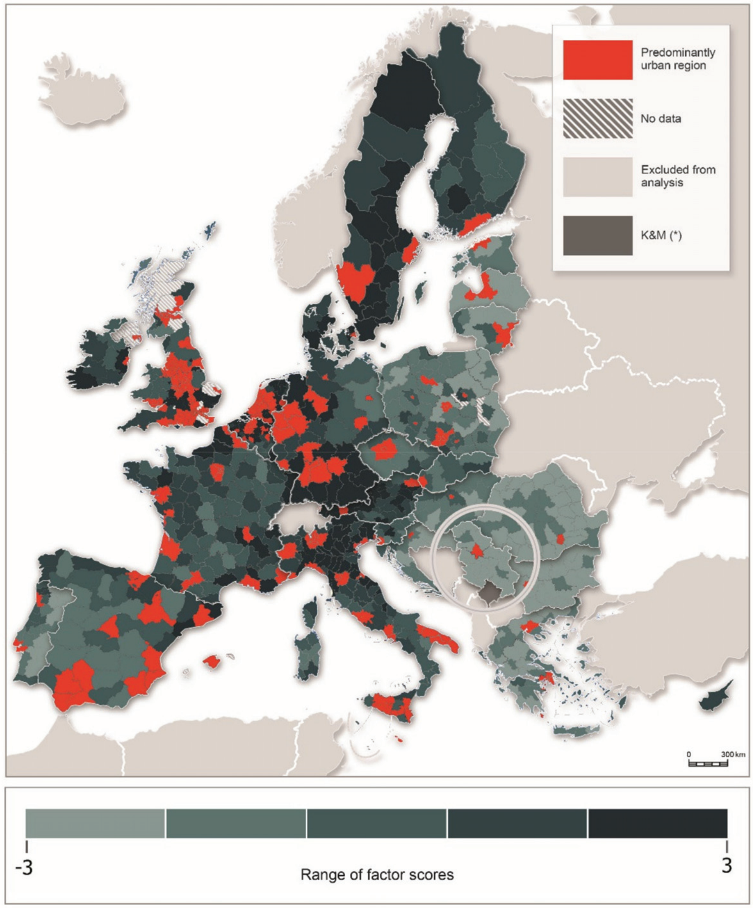

Figure 1. Index of Socioeconomic Performance of regions in EU plus Serbia as candidate for membership. Source: Author processed based on results of FA. Note: The specific status of Kosovo and Metohija excluded it from the analysis. Adobe Photoshop CC 2015 and NUTS 3 maps of the European Commission were used.

5. Discussion

From the country-level perspective, most EU countries have regions with different socioeconomic performance and range from Group 1 to Group 5 (such as Italy). Two exceptions are the Netherlands and Sweden, whose regions are mostly classified as part of Group 5 and in some cases Group 4. However, in countries such as Serbia, Romania, Bulgaria, Croatia, Latvia, and Estonia, all regions are classified as Groups 1 and 2 (the lowest socio-economic performance). These countries are characterized by the centralized development of the regions around their capital cities (usually the only predominantly urban region). The large gap between capital regions and other regions within one country indicates significant pressure on the capital region to pull development from other regions, often leaving resources in other regions untapped. Such regional inequalities within countries' borders are defined in relation to the capital city–other regions.

Some countries have clear north–south and east–west divisions. In Italy, for example, most regions in the north fall into Group 5, and on Figure 1 they are marked with the darkest colour. This part of Italy is an industrial and service centre, whereas southern

Italy is not. Germany is another example of this east-west division, and is one where inequality between east and west has been an important issue in regional policy since the fall of the Berlin Wall. Unemployment is more prevalent in the east and young and educated people most often most often migrate west. A declining birth rate in the area of the former East Germany and restructuring of the economy has further deepened these divisions [53]. In some countries, regional development mismatches are present as a consequence of historical circumstances, as noted by Biczkowski et al. [54] in the example of Poland. Additionally, according to Adamowicz [55], the Polish regions in the east are less developed and have poorer socioeconomic performances. Gorzelak [30] argues that regional differences in CEE countries draw on legacies from the earlier period and that, within most newly formed countries, there are significant regional differences in which the eastern parts are less economically developed than those in the west of the countries. This is attributed to the proximity of western regions to the highly developed EU-15 countries, and that the positive economic effects have "spilled over" into the western regions of these newer members. According to Figure 1, this appears to be the case in Poland as well as in the regions of the former Socialist Federal Republic of Yugoslavia (SFRY), which now belong to the separate countries of Slovenia, Croatia, and Serbia (the other former SFRY countries, Northern Macedonia, Bosnia and Herzegovina and Montenegro, were not included in the analysis). Specifically, the best socioeconomic performance was identified in the intermediate and predominantly rural regions of Slovenia. This could be due to the fact that the Slovene private sector has historically been one of the largest recipients in Central and Eastern Europe of financing from highly developed countries [56].

There was also a clear difference in the level of socioeconomic performance between the EU-15, and especially in the area encompassing Northern Italy, Austria and Germany, part of France, the Benelux, the United Kingdom, and the NMS. This is the current state of historical patterns of urbanization in the EU and it comprises Europe's metropolitan core. This pattern was observed as far back as 1989, when a group of French geographers, led by Roger Brunet, defined an area of Europe, later referred to as the "Blue Banana", that was highly urbanized and industrialized, and which connected regions from Manchester and London in the United Kingdom to Lombardy in Italy, passing through the Benelux countries, France, and the western part of Germany and Austria [29].

Of course, these regional differences between the EU-15 and NMS do not apply to all CEE regions (e.g., Czech Republic, Slovakia, Slovenia, and Poland). Mostly the regions near the capitals are able to offer better conditions for the development of other branches of the economy (tourism, trade, the financial sector, etc.). As is illustrated in Figure 1, the eastern part of the EU from the Baltic countries, eastern Poland, Slovakia, Hungary, Romania, Serbia (candidate country), Croatia to Greece, is characterized by areas with the lowest socioeconomic performance, i.e., a high share of the primary sector in employment and GVA, low GDP per capita, and insufficient productivity levels for the entire economy and the primary sector. In some former socialist states, the situation is better, for example in western parts of Poland, the Czech Republic, and Slovakia, while the regions of Romania, Bulgaria, and Serbia are the majority in Group 1, which have the lowest socioeconomic performance, and the highest share of the economy is in the primary sector. According to a European Commission report, some former socialist states have completed the process of agricultural reconstruction through the transfer of labour from agriculture to other sectors (Czech Republic and Slovakia), while in some NMS such as Romania and Bulgaria, during the transition, the share of employment in agriculture increased due to government investment in agricultural enterprises, which were the legacy of the centrally planned economy, in order to reduce unemployment [52].

6. Conclusions

The multidimensional nature of rural areas means that they are extremely heterogeneous in their characteristics, especially across a large EU territorial area, indicating that all relevant features must be an integral part of both development strategies and rural policy making. When viewed according to other aspects, the division of NUTS 3 according to the EU classification into predominantly urban, intermediate, and predominantly rural areas using only population density does not in fact indicate a particular level of development. Classifications based on a single indicator do not adequately represent the EU's geographical area or rural areas. According to the EU classification, predominantly rural areas of Serbia cannot be compared to predominantly rural areas of Germany, Belgium, Netherland and other highly developed EU countries, especially in terms of socioeconomic performance. All districts in Serbia lagged economically, they were more similar to districts in the NMS, so the main hypothesis of this research was accepted. Comprehensive research is important for improving knowledge for the process of transforming Serbia's rural areas. Our empirical research was formulated in accordance with current methods confirmed in the international literature, which enabled a higher level of understanding of the heterogeneity of rural areas in Serbia and of the main trends present in these areas. The **practical implication** of this is reflected in the application of rural typology at the regional level through the Index of Socioeconomic Performance in the creation of measures of national policies and, specifically, rural development policy measures.

All strategies aimed at rural sustainable development must incorporate and utilize Serbia's as an EU candidate. Considering that the main goal of the EU's rural development policies is to preserve the vitality of rural areas as well as to improve the primary sector in Serbia, it would be strongly advisable for Serbia to apply the European model of agriculture, which is based on competitiveness, multifunctionality, and sustainability. In the sphere of agriculture, the core idea of multifunctionality highlights the various roles agriculture plays. In addition to food production, it involves high food quality by implementing good agricultural practices as well as preservation of the natural environment, which thus contributes to the economic and social development of both villages and of society as a whole.

The research indicated a regional development gap in most rural regions of Serbia in relation to more developed EU countries. This implies the need to abandon the centralized development model with the capital as the centre of decision making. Furthermore, this research can help other candidate countries, such as Montenegro, Albania, North Macedonia, and Turkey, determine their regions' position in relation to EU regions.

The **originality** of the research was reflected in the approach, which, when it comes to rural regions of Serbia, is not widely represented in the literature. The research of the rural area of Serbia was mostly sector-oriented, while the spatial approach was still in the background. Moreover, the most comprehensive research that analysed the rural areas of Serbia was conducted by Bogdanov et al. [57], but there was no study that dealt with the socioeconomic characteristics of rural regions of Serbia and their comparison with EU countries. Therefore, this paper filled the gap in the literature.

It is clear that the research into development processes in rural areas implies an integrated approach with the use of a much larger number of indicators. However, due to the available data in databases, this paper's main **limitation** was the usage of a scarce number of variables.

Future research will move towards identifying other factors contributing to the heterogeneity of rural regions, including demographic and spatial factors. This would mean responding appropriately to the demand for multidimensional access to rural areas in order to create a rural typology that would encompass Serbia and the EU at the regional level. Rural typology at the regional level could point to certain spatial patterns in the development of Serbia's rural areas relative to the EU countries.

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References

1. European Commission. Modernising and Simplifying the CAP: Socio-Economic Challenges Facing EU Agriculture and Rural Areas. Brussels. 2017. Available online: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/soc_background_final_en.pdf (accessed on 10 June 2021).
2. Organisation for Economic Co-Operation and Development. Rural 3.0. A Framework for Rural Development. Policy Note. 2018. Available online: https://www.oecd.org/cfe/regional-policy/Rural-3.0-Policy-Note.pdf (accessed on 15 July 2021).
3. López-Sanz, J.M.; Penelas-Leguía, A.; Gutiérrez-Rodríguez, P.; Cuesta-Valiño, P. Sustaina-ble Development and Rural Tourism in Depopulated Areas. *Land* **2021**, *10*, 985. [CrossRef]
4. Berc, G.; Kokorić, B.S.; Opačić, A. Dostupnost socijalnih prava i usluga za obitelji u općinama u ruralnim područjima Hrvatske. *Rev. Za Soc. Polit.* **2020**, *27*, 113–135. [CrossRef]
5. Böwer, U.; Turrini, A. EU accession: A road to fast-track convergence? *Comp. Econ. Stud.* **2010**, *52*, 181–205. [CrossRef]
6. Zekić, S.; Kleut, Ž.; Matkovski, B. An analysis of key indicators of rural development in Serbia: A comparison with EU countries. *Econ. Ann.* **2017**, *62*, 107–120. [CrossRef]
7. Matkovski, B.; Zekić, S.; Jurjević, Ž.; Đokić, D. The agribusiness sector as a regional export opportunity: Evidence for the Vojvodina region. *Int. J. Emerg. Mark.* **2021**. [CrossRef]
8. Petrović, M.D.; Vujko, A.; Gajić, T.; Vuković, D.B.; Radovanović, M.; Jovanović, J.M.; Vuković, N. Tourism as an approach to sustainable rural development in post-socialist countries: A comparative study of Serbia and Slovenia. *Sustainability* **2018**, *10*, 54. [CrossRef]
9. Erjavec, E.; Volk, T.; Rednak, M.; Ciaian, P.; Lazdinis, M. Agricultural policies and European Union accession processes in the Western Balkans: Aspirations versus reality. *Eurasian Geogr. Econ.* **2021**, *62*, 46–75. [CrossRef]
10. Kurowska, K.; Kryszk, H.; Marks-Bielska, R.; Mika, M.; Leń, P. Conversion of agricultural and forest land to other purposes in the context of land protection: Evidence from Polish experience. *Land Use Policy* **2020**, *95*, 104614. [CrossRef]
11. Kurowska, K.; Marks-Bielska, R.; Bielski, S.; Aleknavičius, A.; Kowalczyk, C. Geographic Information Systems and the Sustainable Development of Rural Areas. *Land* **2021**, *10*, 6. [CrossRef]
12. Gabrić-Molnar, I.; Kovács, T. Support to the economic development of Vojvodina from Hungary. *Anal. Ekon. Fak. u Subotici (The Annals of the Faculty of Economics in Subotica)* **2019**, *55*, 3–15. [CrossRef]
13. European Commission. *Serbia 2019 Report. 2019 Communication on EU Enlargement Policy*; European Commission: Brussels, Belgium, 2019.
14. Zekić, S.; Matkovski, B.; Kleut, Ž. IPARD funds in the function of the development of the rural areas of the Republic of Serbia. *Ekon. Horiz.* **2016**, *18*, 169–180. [CrossRef]
15. Jurjević, Ž.; Bogićević, I.; Đokić, D.; Matkovski, B. Information technology as a factor of sustainable development of Serbian agriculture. *Strateg. Manag.* **2019**, *24*, 41–46. [CrossRef]
16. European Commission. *Methodological Manual on Territorial Typologies*; Publications Office of the European Union: Luxembourg, 2018; ISBN 978-92-79-94874-9; ISSN 2315-0815. [CrossRef]
17. Golić, R.; Joksimović, M. Regionalization of Serbia as an instrument of balanced regional development and reduction of regional inequalities. *Zb. Rad.-Geogr. Fak. Univ. U Beogr.* **2017**, *65-1a*, 209–226. [CrossRef]
18. Darvas, Z.; Mazza, J.; Midoes, C. *How to Improve European Union Cohesion Policy for the Next Decade*; No. 2019/8; Bruegel Policy Contribution: Brussels, Belgium, 2019.
19. Pagliacci, F.; Pavone, P.; Russo, M.; Giorgi, A. Regional structural heterogeneity: Evidence and policy implications for RIS3 in macro-regional strategies. *Reg. Stud.* **2019**, *54*, 765–775. [CrossRef]
20. European Commission. *Eurostat Regional Yearbook*; Publications Office of the European Union: Luxembourg, 2019.
21. European Commission, *EAFRD Financial Instruments in 2014–2020 Rural Development Programmes—Final Report*; European Commission: Brussels, Belgium, 2018.
22. Matthews, A. *The EU's Common Agricultural Policy Post 2020: Directions of Change and Potential Trade and Market Effects*; International Centre for Trade and Sustainable Development (ICTSD): Geneva, Switzerland, 2018; ISSN 1817-356X.
23. Vukadinović, S.; Ješić, J. Green jobs: Potential for employment in the Republic of Serbia. *Anal. Ekon. Fak. u Subotici (The Annals of the Faculty of Economics in Subotica)* **2019**, *55*, 115–129. [CrossRef]
24. Mitrović, J.; Mitrović, V. The development of social entrepreneurship and the perspective of its further affirmation in the overall development of Serbia. *Anal. Ekon. Fak. u Subotici (The Annals of the Faculty of Economics in Subotica)* **2019**, *55*, 81–97. [CrossRef]
25. Vincze, M.; Mezei, E. The increase of rural development measures efficiency at the micro-regions level by cluster analysis. A Romanian case study. *East. J. Eur. Stud.* **2011**, *2*, 13–39.

26. Michalek, J.; Zarnekow, N. Application of the rural development index to analysis of rural regions in Poland and Slovakia. *Soc. Indic. Res.* **2012**, *105*, 1–37. [CrossRef]
27. Prus, P.; Dziekanski, P.; Bogusz, M.; Szczepanek, M. Spatial Differentiation of Agricultural Potential and the Level of Development of Voivodeships in Poland in 008-2018. *Agriculture* **2021**, *11*, 229. [CrossRef]
28. Domazet, I.; Zubović, J.; Lazić, M. Driving Factors of Serbian Competitiveness–Digital Economy and ICT. *Strateg. Manag.* **2018**, *23*, 20–28. [CrossRef]
29. Annoni, P.; Dijkstra, L.; Gargano, N. *EU Regional Competitiveness Index (RCI 2016)*; Publications Office European Commission: Brussels, Belgium, 2017.
30. Gorzelak, G. Regional Policies in East-Central Europe. In *Handbook of Regional Science*; Fischer, M., Nijkamp, P., Eds.; Springer: Berlin, Germany, 2020. [CrossRef]
31. Bachtler, J.; Ferry, M. Cohesion policy in central and Eastern Europe. Is it fit for purpose? In *Social and Economic Development in Central and Eastern Europe: Stability and Change after 1990*; Gorzelak, G., Ed.; Routledge: New York, NY, USA; London, UK, 2020.
32. Sánchez-Zamora, P.; Gallardo-Cobos, R.; Ceña-Delgado, F. Rural areas face the economic crisis: Analyzing the determinants of successful territorial dynamics. *J. Rural. Stud.* **2014**, *35*, 11–25. [CrossRef]
33. Dyba, W.; Loewen, B.; Looga, J.; Zdražil, P. Regional development in Central-Eastern European countries at the beginning of the 21st century: Path dependence and effects of EU Cohesion Policy. *Quaest. Geogr.* **2018**, *37*, 77–92. [CrossRef]
34. Volk, T.; Rednak, M.; Erjavec, E.; Zhllima, E.; Gjeci, G.; Bajramovic, S.; Gjokaj, E. *Monitoring of Agricultural Policy Developments in the Western Balkan Countries*; No. JRC105784; Joint Research Centre (Sevillesite): Ispra, Italy, 2017. [CrossRef]
35. Papić, R.; Bogdanov, N. Rural Development Policy—A perspective of local actors in Serbia. *Econ. Agric.* **2015**, *62*, 1079–1093. [CrossRef]
36. European Commission. *LEADER Local Development Strategies (LDS) Guidance on Design and Implementation*; Publications Office of the European Union: Luxembourg, 2016. Available online: https://enrd.ec.europa.eu/sites/enrd/files/enrd-guidance_lds.pdf (accessed on 10 June 2021).
37. Balog, K. The concept and competitiveness of agile organization in the fourth industrial revolution's drift. *Strateg. Manag.* **2020**, *25*, 14–27. [CrossRef]
38. Martinović, M.; Ratkaj, I. Sustainable rural development in Serbia: Towards a quantitative typology of rural areas. *Carpathian J. Earth Environ. Sci.* **2015**, *10*, 37–48.
39. Harrington, V.; O'Donoghue, D. Rurality in England and Wales 1991: A replication and extension of the 1981 rurality index. *Sociol. Rural.* **1998**, *38*, 178–203. [CrossRef]
40. Hair, J.; Black, W.; Babin, B.; Anderson, R. *Multivariate Data Analysis—A Global Perspective*; Pearson: London, UK, 2014; ISBN 10: 1-292-02190-X, ISBN 13: 978-1-292-02190-4.
41. Osborne, J.W. What is rotating in exploratory factor analysis? *Pract. Assess. Res. Eval.* **2015**, *20*, 2.
42. Cloke, P.; Edwards, G. Rurality in England and Wales 1981: A replication of the 1971 index. *Reg. Stud.* **1986**, *20*, 289–306. [CrossRef]
43. Hedlund, M. Mapping the socioeconomic landscape of rural Sweden: Towards a typolgy of rural areas. *Reg. Stud.* **2016**, *50*, 460–474. [CrossRef]
44. Camaioni, B.; Esposti, R.; Lobianco, A.; Pagliacci, F.; Sotte, F. How rural is the EU RDP? An analysis through spatial fund allocation. *Bio-Based Appl. Econ.* **2013**, *2*, 277–300. [CrossRef]
45. Pinto-Correia, T.; Guiomar, N.; Guerra, C.A.; Carvalho-Ribeiro, S. Assessing the ability of rural areas to fulfil multiple societal demands. *Land Use Policy* **2016**, *53*, 86–96. [CrossRef]
46. Pagliacci, F. Regional paths towards Europe 2020 targets: A spatial approach. *Eur. Plan. Stud.* **2017**, *25*, 601–619. [CrossRef]
47. Tercet (2017) Regulation (EU) 2017/2391 of the European Parliament and of the Council of 12 December 2017 Amending Regulation (EC) No 1059/2003 as Regards the Territorial Typologies, Official Journal of the European Union. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32017R2391 (accessed on 5 June 2021).
48. Copus, A.; Noguera, J. *A typology of intermediate and predominantly rural NUTS 3 regions. EDORA Scientific Working Paper No. 24. EDORA Final Report, Annex 1 (Part C: Scientific Working Papers)*; ESPON: Luxembourg, 2013.
49. Eurostat, Employment (Thousand Persons) by NUTS 3 Regions. Available online: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10r_3empers&lang=en%20[Database:%20Nama_10r_3empers]. (accessed on 5 December 2019).
50. Eurostat, Gross Domestic Product (GDP) at Current Market Prices by NUTS 3 Regions. Available online: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10r_3gdp&lang=en%20[Database:%20Nama_10r_3gdp]. (accessed on 5 December 2019).
51. Eurostat, Gross Value Added at Basic Prices by NUTS 3 Regions. Available online: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10r_3gva%20[Database:%20Nama_10r_3gva]. (accessed on 5 December 2019).
52. The European Network for Rural Development, Employment and Social Inclusion. 2010. Available online: https://enrd.ec.europa.eu/sites/enrd/files/09AED062-D99D-0744-062C2B6F6E4785FB.pdf (accessed on 15 June 2021).
53. Spellerberg, A.; Huschka, D.; Habich, R. Quality of life in rural areas: Processes of divergence and convergence. *Soc. Indic. Res.* **2007**, *83*, 283–307. [CrossRef]
54. Biczkowski, M.; Jezierska-Thöle, A.; Rudnicki, R. The Impact of RDP Measures on the Diversification of Agriculture and Rural Development—Seeking Additional Livelihoods: The Case of Poland. *Agriculture* **2021**, *11*, 253. [CrossRef]

55. Adamowicz, M. The Potential for Innovative and Smart Rural Development in the Peripheral Regions of Eastern Poland. *Agriculture* **2021**, *11*, 188. [CrossRef]
56. Karo, E.; Kattel, R. Economic development and evolving state capacities in Central and Eastern Europe: Can "smart specialization" make a difference? *J. Econ. Policy Reform* **2015**, *18*, 172–187. [CrossRef]
57. Bogdanov, N.; Meredith, D.; Efstratoglou, S. A typology of rural areas in Serbia. *Ekon. Anal.* **2008**, *53*, 7–29. [CrossRef]

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Profile of a Modern Hunter and the Socio-Economic Significance of Hunting in Poland as Compared to European Data

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Abstract: Hunting is a unique form of activity in rural areas with a high proportion of forest areas, which involves nature conservation and meets social needs for recreation and the preservation of traditions while being an important part of economic activity. The presented study results, based on a literature review and questionnaire surveys conducted among hunters associated in hunting clubs in the north-eastern part of Poland, provide the basis for a discussion on the socio-economic significance of hunting, both in the country and throughout the European continent. Based on the results presented in the paper, it can be concluded that the number and density of hunters differ in individual countries. Moreover, hunting is practised in Europe by almost 7 million people, of which 127,000 are in Poland, and is a typical male activity. Most hunters in Poland and other European countries are professionally active inhabitants of rural areas, aged approximately 50 years, with several years of shooting experience and an income exceeding average values. Hunting is an important part of socio-economic activities, particularly in rural areas. It is estimated that in the EU alone, hunting can be worth approximately EUR 16 billion, and creates 100–120 thousand jobs. The most recent results of studies conducted in certain EU countries and the wide range of services provided by the hunting sector indicate that these values may be considerably higher. Regarding Poland, despite the centralised game resource management system, there are no extensive studies of the economic significance of hunting, and the official data are limited to a few basic indices related to hunting statistics. As indicated by the study results presented in this paper, in Poland, hunting-related expenditures are clearly lower than the European average and, thus, the economic significance of hunting is relatively low in this country. Despite this, it is a hunting community that, as a result of the adopted system solutions, is responsible for the functioning of reasonable game management while significantly affecting the management of the vast majority of rural areas.

Keywords: rural development; hunting grounds; rural areas

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1. Introduction

1.1. Legal Aspects and Hunting Management in the EU and Poland

Over the centuries, hunting has undergone major shifts. Gradually, it ceased to be the primary source of food supply and became a way of spending free time [1,2]. Currently, in Poland and in the majority of European countries, hunting is a form of nature conservation aimed primarily at adapting the wild animal population to a habitat being constantly changed by humans. Hunting also aims to satisfy social needs regarding the maintenance of traditions and the propagation of hunting ethics and culture [3–5].

Although hunting raises a lot of legal and ethical controversies in many social circles (particularly as regards trophy hunting), and there is no convincing evidence that recreational hunting contributes to sustainable conservation tasks in each case [6–9], it should be noted that in all European countries, irrespective of the motivation and acceptable methods, it is a legal way to harvest wild natural resources. The legal framework for hunting in the European Union is rather complex. There are a number of legal documents (directives) which, in many cases, are the result of international agreements and the acts derived from them (regulations and decisions) that affect the internal law of each participating EU country. They primarily govern the rules for hunting management and the hunting methods for the sustainable (reasonable) use of natural resources. This primarily applies to the implementation of the so-called Nature Directives (the "Birds" and "Habitat" Directives [10,11]) to manage populations at a level that does not threaten the normal development of game animals, particularly protected species. However, there is no common EU law to govern the common game management of all the EU countries at the lowest level, and there is still the internal issue of the implementation of justified deviations from the regulations issued in each Member State (this applies, e.g., to the list of huntable species or the hunting period) [5]. Nevertheless, modern hunting rules in the European Union are, for the most part, based on the approach set out in the European Charter on Hunting and Biodiversity by the Council of Europe in Strasbourg on 26–29 November 2007 [3].

The above-described situation is currently the case in Poland. Sustainable wild animal population management is achieved in Poland through the application of a centralised hunting model which, compared to the different solutions in individual European countries, enables a high level of hunting activity coordination [5,12,13]. Since game animals belong to the State Treasury, legal regulations concerning game management, defined as an activity in the field of protection, breeding, and harvesting of game (Article 4(1) of the hunting law [4], have been established at the central level (currently, the Ministry of Climate and Environment). Moreover, the vast majority of hunting districts in which game management is pursued, excluding the State Forests' game animal breeding centres, are administered by a single social organisation that joins together hunters, i.e., the Polish Hunting Association, and its constituent hunting clubs, which ensures system coherence throughout the country. This also streamlines the system for compiling hunting statistics and transferring data from hunting districts to higher management levels. Game animals are harvested in accordance with hunting plans (both current, i.e., annual and multiannual) that are developed in detail, reviewed, and approved. Illegal shooting and poaching are prevented by the State Hunting Guard. The Polish Hunting Association and its constituent hunting clubs that associate hunters conduct and fund their activities according to the Association's statutes themselves. In addition to the above-mentioned activities, they also include those aimed at improving the living conditions of animals, i.e., wildlife food plots, buffer plots, meadow reconstruction and mowing, supplementary winter feeding, etc. A major activity is the payment of compensation for damage caused by wild animals. The system has been in place for many years and appears to have been well-organised for most of that period [4,13,14]. However, in recent years, due to the detection of multiple uncertainties (e.g., incorrect estimation of game animals and financial ambiguities), it has been subject to stricter controls by the State institutions [12,15,16].

It should be noted that the most significant difference in game management between most EU countries and Poland is the inseparability of land ownership rights and the right to exercise hunting. If a landowner is entitled to exercise hunting and wants to exercise it on their own land, they can do so, but they also have the option of leasing this right to third parties for remuneration. In both cases, it is the owner that reaps the full benefits of the land they own. The amount of game to be harvested, i.e., the number of animals culled (harvest permits), is usually determined by external bodies that monitor wildlife welfare. As in Poland, lease agreements in most European countries are multiannual; the only difference is that in Poland (but also, for example, in Hungary and Italy), it is not the landowner that benefits from hunting [5,12,13].

1.2. Social and Economic Significance of Hunting Worldwide

According to the data provided by the largest hunting organisation in Europe, i.e., the European Federation for Hunting and Conservation (FACE), whose members are national hunting associations from 37 European countries, including the EU-28, there are currently over seven million hunters in Europe, which makes is the second-largest formally organised hunting population, after the United States of America [17]. The numbers and densities of hunters vary from country to country and even from region to region, which often reflects local hunting traditions, land uses or political circumstances. Consequently, the hunting community represents a diverse group of various social and cultural circles that combines multiple notions and values. In general, a passion for nature and hunting motivates hunters and hunting communities to take a proactive approach to nature conservation. Hunting in the EU alone is estimated to contribute to the management of over 65 per cent of rural areas. It takes place in cooperation with landowners, farmers, foresters and other stakeholders, thus creating an extensive social network involved in nature and landscape management [18].

Hunting is an important socio-economic activity, particularly in rural areas. Recent research reports suggest that in the EU alone, hunting is worth approximately EUR 16 billion [18]. A detailed analysis of hunting expenditures in North America demonstrated an even greater significance and financial contribution of almost 30 billion to the local and national economy. Hunters provide financial support by creating thousands of jobs directly related to the production and sale of goods and services intended to meet their needs. In addition, the expenditures accompanying hunting trips benefit hundreds of thousands of people employed in local shops, restaurants and hotels [19]. Apart from direct expenditures and the creation of jobs, hunting has an additional economic value. The revenue generated from excise taxes imposed on hunting and equipment and from licence fees, support nature conservation and its sustainable management [19].

The above-mentioned data concerning the economic impact of hunting in Europe are estimates. This is due to the fact that individual EU countries are not obliged to draw up and report such lists. Due to having different hunting organisation systems in place, they acquire information in different manners and report differently on game management [5,12,14,18,20].

In view of the above-mentioned differences in the organisation of game management in individual countries, no mechanisms enabling a precise assessment of the value of hunting and its contribution to the EU economy have yet been conducted. The situation is similar as regards the characteristics of hunters. The available socio-economic data concerning hunters in individual European countries are, in most cases, very general or several years old. A good example is the data provided on FACE websites, which, in most cases, date back to the end of the 20th and the beginning of the 21st century, and are most often limited to the presentation of the number of hunters in individual countries as well as their gender [21]. Only a few of the largest hunting associations, e.g., in Spain, Germany, France and the United Kingdom, in recent years have conducted reliable sociological studies on hunters, also determining the scale of their expenditures, and published them on their websites [22–25].

In Poland, thanks to the centralised hunting model, there are accurate data available on hunting statistics, including the value of harvested animals and the compensation for hunting damage. On the other hand, there are no extensive, reliable data on the economic value of hunting. The situation is similar for the characteristics of hunters.

The determination of the economic consequences of hunting, and the identification of groups of users involved in the management of wildlife resources is critically important in the context of management improvements and political decisions related to hunting and biodiversity conservation [18,26,27]. The socio-economic benefits generated by hunting are becoming even more important in the context of rural development. In many underindustrialised regions of the world, tourism, including hunting tourism, is an important form of activity that contributes to an improvement in the living conditions of the local population [28,29].

The aim of the study is to attempt to show the socio-economic profile of the hunter as well as the social and economic dimensions of hunting in Poland against the background of this social phenomenon in other parts of Europe.

2. Materials and Methods

Given the selective and, in most cases, outdated statistical and literature data concerning the characteristics of hunters in Poland, the acquisition of data describing this social group was based on the diagnostic survey method. The study involved hunters hunting in different parts of north-eastern Poland. The area selected for the study, comprising several dozen hunting districts of Warmińsko-Mazurskie Voivodeship, is characterised by very favourable conditions for hunting (the percentage of agricultural land in a particular area is about 40%, and that of forests is about 50%), and the percentage ratio of hunters to the general population is one of the highest in Poland [30] (Figure 1).

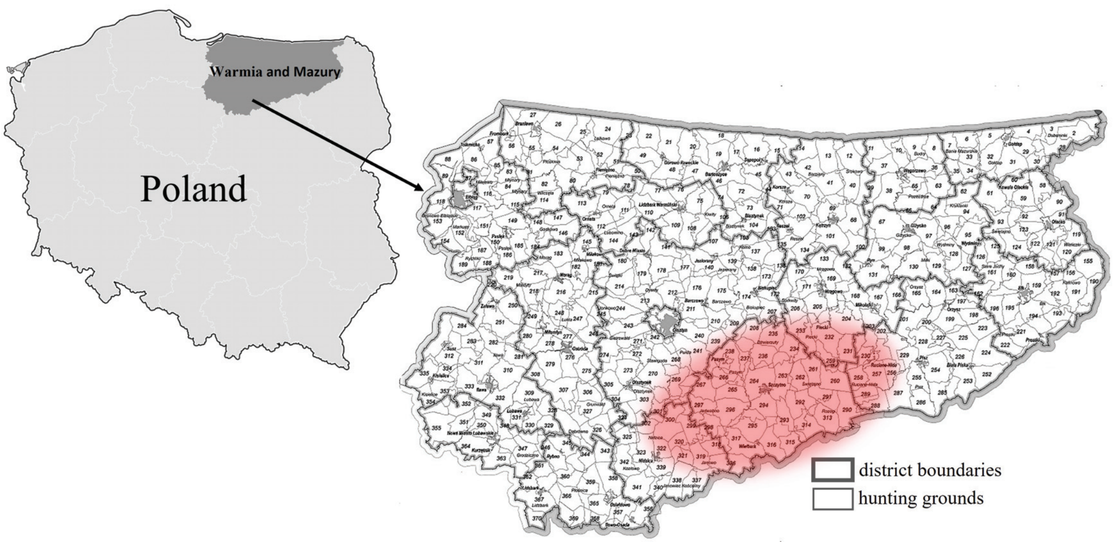

Figure 1. The area covered by the diagnostic survey (red area).

Structured interviews with hunters were conducted from January to March 2019. The study was conducted alongside hunting meetings and events held in the field. Participation in the study was voluntary and anonymous, and the only prerequisite was to conduct hunting activity. The interviews began with a short description explaining the goals and background of the study. The questions asked were intended to determine the demographic and sociological profile of the group under study (i.e., gender, age, place of residence, educational background, professional status and hunting experience), the level of the income earned and the annual expenditures on hunting-related purposes. The thematic scope of the questions and the study performance method were drawn from studies on angling after adjusting them for hunting [31,32].

An important supplement of the study was an analysis of statistical and literature data dedicated to various social aspects (including changes in the number of hunters) and economic aspects (hunting expenditures, the share in the GDP and employment) of hunting in Europe. For this reason, the most recent publicly available reports, studies and articles on hunting were used. What was also helpful was an analysis of websites of hunting associations in individual European countries, primarily the information gathered and made public by the FACE. The presented review and synthesis of literature data concerning the social and economic aspects of the hunting effects were not aimed at their detailed analysis in individual countries, but instead at demonstrating the most recent empirical evidence on the scale of economic effects and the significance of hunting for the economy of Poland and other EU countries.

3. Results and Discussion

3.1. The Number of Hunters: Current Status and Trends

The hunting population size and its changes over time are important for the management of wild animal populations. According to official statistics, there are 127,426 hunters in Poland (i.e., 1.9% of all the hunters registered in the EU), associated in 2705 hunting clubs that lease 4622 field and forest hunting districts covering an area of 25,216.5 thousand [30]. Despite the vast areas in which hunting is permitted (approximately 82% of the area of Poland), hunters account only for 0.32% of the population, i.e., there is one hunter for every 313 citizens living in Poland. In the European Union, in which approximately 5.9 million hunters are registered, these values are clearly higher and amount to 1.14% and 87, respectively [30,33].

Recent statistical data and the data published by the FACE indicate that the popularity of hunting, measured by the ratio of hunters to the general population, is the greatest in Scandinavian countries and in southern countries with Romance culture [33–35]. In Scandinavia, where the hunters-to-inhabitants ratio is below 1:36, hunting has an eminently recreational and somewhat trapper-like character. In the latter group of countries (including France, Spain, Portugal and Greece), this ratio is slightly higher yet still below the average for the EU (1:87). These are countries with a low intensity of game management, an organisational system that is often licence-based and district-free and places high hunting pressure on the fauna. Poland is among other countries such as Switzerland, Germany, Romania, Belgium and the Netherlands with a very high inhabitants-to-hunters ratio (above 200). These are countries with a long tradition of hunting based on the feudal model [33,34].

In recent decades, a downward trend in the hunting population has been noticeable in Europe. The most pronounced drop (several percent) was observed in the 1990s and particularly concerned certain countries in southern Europe, where hunting was very popular (e.g., Spain, France and Italy). This trend clearly slowed down after 2006. Since then, in most cases, the stabilisation of the trend or an increase in the number of hunters could be observed [36–38]. A good example of a slow, yet systematic increase in the number of hunters in the last decade are the Central European countries, particularly Germany, Austria and Poland [24,39,40]. The hunting populations in individual countries and their changes over time are a result of many factors. These are primarily determined by the legal and administrative rules, the natural conditions for practising hunting, economic factors (e.g., hunting-related fees) and sociological determinants [18,34,36]. It should be stressed that the public acceptance of any form of recreational hunting, even involving invasive alien species, is currently lower than at any time in the past, with concerns about animal welfare and animal rights being predominant in discussions and ethical considerations about the moral implications of hunting for pleasure. The controversial nature of modern hunting lies in the questioning of the advisability of killing animals and methods that fail to harmonise with current ethical and legal standards regarding slaughter and killing [8,9]. The relatively low popularity of hunting in Poland is largely due to legal, administrative and economic factors. The complex, time-consuming and costly procedures for obtaining hunting permits (long-term and expensive training, and restrictive requirements to obtain a permit for hunting weapons) [13,41].

3.2. Sociological Characteristics of Hunters

The available European statistics and literature mainly present the basic demographic and sociological data that characterise hunters. For the most part, they only concern the hunters' gender and age. The study conducted for the purposes of this paper involved 100 hunters and aimed at determining the socio-economic profile of hunters. All study participants were members of local hunting clubs. The most important socio-demographic data describing the hunters in this study are provided in Table 1. The data reveal that the vast majority of hunters, i.e., more than 95%, are men (Table 1). According to the data presented by the Polish Hunting Association, 97% of hunters in Poland are men [40].

Table 1. Socio-demographic profile of hunters from the studied Region of Warmia and Mazury.

Item	Options	Percentage
Gender	Female	5
	Male	95
Age (years)	<18	0
	18–25	15
	26–40	36
	41–60	49
	>60	18
Education background	Basic	4
	Vocational	18
	Secondary	48
	Higher	30
Professional status	Unemployed	0
	Student	10
	Active	68
	Retired	22
Place of residence	City	39
	Village	61
Hunting experience (years)	<5	17
	5–10	14
	11–20	24
	21–30	20
	>30	25
Total		100

Studies conducted in other parts of the world also indicate that hunting is a typical male activity, while the percentage of actively hunting women is negligible. A small percentage of female hunters, similar to that provided in Polish data, is found in most other EU countries. Examples are found in Finland and Austria, where approximately 10% of hunters are women [27,39]. Despite the clear male predominance, a few countries have seen a noticeable increase in interest in hunting on the part of women in recent years. This is particularly observed in the countries with the general increase in the number of hunters (e.g., in Germany, Austria and Poland). Every indication is that this phenomenon is mostly contributed to by the promotional activities of hunting associations in which the crucial argument appears to be the environmental benefits provided by hunters [24,39].

For legal reasons, one must be an adult to hunt. The age of almost half of the hunters under study ranged from 40 to 60 years (with an average age of 47 years). According to the Polish Hunting Association data, the average age of hunters in Poland is 52 years [40]. The situation in this respect is similar in other European countries where fifty-year-olds have long been the largest group of hunters [23,24,27].

Similarly to the situation, e.g., in France, Germany or Spain, the largest portion of hunters in the region of Poland under study comprises persons with secondary or higher education and professionally active, while the percentage of students is low. In most cases, hunters are also inhabitants of villages and rural areas (Table 1) [23–25,27]. The results obtained in this study are consistent with the European data, also in terms of the hunters' experience. The available data indicate that the vast majority of hunters have been interested in this activity for several years, and the data from Spain, France and Germany also show that the main reason for their interest in hunting has been family traditions [23,24,27,42].

3.3. Economic Aspects of Hunting

Hunters make a contribution to all major sectors of the economy, both directly and indirectly. For example, they compensate farmers for crop damage in the primary sector, purchase equipment from the secondary sector and pay for tourism services in the tertiary sector. As a result of generating these values, and in order to sustain hunting, a certain amount of money and other resources is also reinvested in the conservation or restoration of habitats and wild animal populations [18].

All the available data about the contribution of hunting to the economy refer mostly on hunters' hunting expenditures, acquired using questionnaire surveys. In the 1990s, the data obtained from a few Western European countries indicated that, on average, a single hunter spends approximately an average of EUR 1500 per annum on their hobby [34]. The research conducted at the end of the subsequent decade, this time involving hunters from all EU Member States at that time, showed an amount of EUR 2500 [43]. All expenses related to hunting, e.g., licences, leases, weapons and ammunition, equipment and trips, were considered. However, no social aspects or those related to nature conservation were taken into account. The average value of a hunter's expenditures, extrapolated to the entire hunter population (approximately 6.6 million people), amounts to EUR 16 billion and is the amount most frequently quoted in FACE reports as the economic value of hunting in Europe.

It is worth mentioning that, in addition to the level of an average hunter's expenditures, the above-cited paper [43] also reports on a varied level of expenditure declared by the respondents. They ranged from EUR 700–4300, but without indicating the expenditures in individual countries [43]. The current level can be estimated in individual countries from websites of individual national hunting associations. In-depth studies dedicated to these issues have been conducted in the last decade, inter alia in the United Kingdom, France, Spain and Germany, i.e., in countries where hunting is very popular, or its popularity is on the increase. The average hunter's expenditures in the indicated countries exceed the above-cited European average, yet they do not differ significantly from the upper range limit indicated. For example, the amount is EUR 2800 in France, GBP 2000 in the United Kingdom, and EUR 4340 in Germany [22–25]. The situation is different in Spain, where the expenditures declared by hunters are almost four times greater than the average value (EUR 9649). The data from Spain present the component structure of the expenditures with exceptional accuracy. An interesting fact is that for an average of 27 hunting trips in a year, almost half of the amount of EUR 9649 declared by hunters covers expenditures on transport (including car maintenance), accommodation (including second house maintenance) and food [25].

As for Poland, the official economic hunting-related data list the quantity and values of the procurement of game animals and the compensation paid from the sources of managers or leaseholders of hunting districts for losses in agricultural crops and the damage caused by hunting. In 2020, these values amounted to PLN 108,432,400 (approximately EUR 25 million) and PLN 92,603,200 (approximately EUR 21.5 million), respectively [30]. In contrast, there is no information on the expenditures of hunters alone or on the contribution of hunting to the national economy. Research conducted for the purpose of this study shows that the average annual expenditures of hunters in Poland, including all expenditures related to hunting, amounts to an average of PLN 2702 (approximately EUR 640) (Table 2).

Table 2. Average annual expenditures directly related to hunting and monthly gross income of hunters from the studied Region of Warmia and Mazury. Values expressed in PLN (Polish New Złoty).

Item	Options	Percentage
Expeditures	<1000	11
	1001–2500	51
	2501–5000	28
	5001–7500	8
	>7500	2
	Average: 2702	
Monthly gross income	<2500	25
	2501–3500	31
	3501–4500	24
	>4500	20
Total		100

When comparing this data with the European data presented above, it can be noted that these values are four times lower than the average and fall just below the lower limit of the expenditure range indicated in 2008 [43]. The observed values and, possibly, the differences in individual countries result from the slightly different (not always recommended) research methodology and are determined by the hunting method and the economic factors, such as the amount of hunting fee or the income earned [18,34]. Regarding the group of hunters from Poland under study, even though the average gross monthly earnings were close to the average level of income in the region under study, they were still a third of the value noted in the EU Table 2 [43,44]. It is not without significance that the declared expenditure level was undoubtedly affected by the fact that the vast majority of the respondents hunted in close proximity to their place of residence. Hunters in this area usually hunt within a radius of up to 15 km from their place of residence, in hunting districts belonging to the hunting club of which they are members. [45]. It is also worth noting that the reported amount of hunters' expenditures in Poland was greater by more than half of that noted for another group harvesting wild animal resources, i.e., anglers [32,46]. In the case of this group, the vast majority of people in all regions of Poland practise their hunting activity on a very local basis, using mainly the local environmental resources. If the above-mentioned hunting expenditures were taken as those reflecting the situation throughout the country, and if they were extrapolated to the entire population of 127,000 hunters, the direct expenditures by hunters in Poland would amount to approximately PLN 343 million (approximately EUR 80 million), i.e., less than 0.5% of the expenditures in Europe, estimated at EUR 16 billion [18].

Moreover, in order to get a realistic picture of the economic significance of hunting as a whole, it would be necessary to consider a much broader set of impacts embedded in hunting activities, in addition to the direct hunting expenditures (i.e., for hunting equipment, trips, game animal maintenance, licences, taxes, trophies, etc.). These include the economic, environmental and cultural effects related to species conservation and management, restoration of habitats and land management provided by hunters. Many of these costs would have to be borne by taxpayers to fund the restoration and management of habitats/species, or compensate landowners for damage caused by game animals in the absence of hunting. Other manifestations of the positive impact of hunters and hunter community (including hunters' families, friends, etc.) include the promotion of culture, heritage, tourism, local economy, welfare and voluntary work in activities related to both habitat and wildlife management. Some of these activities are difficult to measure, and most of them, due to methodological difficulties, have not yet been valued [18,27,34].

In recent years, a few European countries have made an attempt to take different activities performed voluntarily by hunters into account in the most characteristic economic indices, e.g., the share in the GDP or the creation of jobs, both those directly and indirectly dependent on hunting. Since some data (based primarily on the direct benefits generated by hunting) suggest that in Europe, one job is generated by 65 hunters, it can be approximated that European hunters support between 100,000 and 120,000 jobs [34]. The most recent research conducted in countries with the greatest numbers of hunters indicates a considerably greater impact of hunting on the economy than that mentioned above. It is estimated that in 2014, in the United Kingdom alone, 600,000 hunters and target shooters spent an estimated GBP 2.5 billion on goods and services, and the total gross value added, related to sport shooting, is estimated at GBP 2 billion (approximately EUR 2.6 billion). It was calculated that this community also creates 74,000 jobs, of which half (35,000) are directly dependent on hunting. Accommodation and catering are the sectors with the largest percentages of these jobs. Nature conservation-related works alone, involving approximately 3.9 million days of conservation work, correspond to 16,000 jobs [20]. In Italy, the annual total costs incurred by 850,000 official hunters is estimated at €3.26 billion, and hunting and shooting further create a little less than 43,000 jobs in total [47]. Similar figures are generated by the French hunting sector. In addition to a turnover of EUR 3.9 billion per annum and EUR 2.3 billion in value added to the national economy (GDP), the activities of 1.1 million hunters guarantee 28,000 permanent jobs, and volunteer works (including activities related to the management of natural habitats and wildlife) create a further 57,000 full-time jobs [23]. Even higher figures are noted for Spain, which is similar to Poland in terms of the area and population. These figures indicate that just over 713,000 people with hunting licences generate almost 1% (187,000) of all jobs [25].

4. Conclusions

According to the data presented in this study, despite the increased interest in hunting in recent years, Poland is among the countries with the relatively smallest number of hunters in the EU. Despite the various levels of hunting popularity throughout Europe, the socio-demographic profile of hunters appears to be very similar. The only factor that appears to clearly differentiate hunters in Poland from hunters from other Western European countries is the relatively low declared expenditures for hunting. This is most probably due to economic factors, and may be linked to the hunting method. Despite the centralised and unified system of hunting management throughout Poland, no attempts have yet been made to determine the economic significance of hunting and its impact on the economy. The results of these studies, even though methodologically different, are available in other European countries. Apart from the indisputable social and economic benefits, it is also important to remember the extremely important ecosystem services provided by hunters, which very often are not known to society, and their final valuation is very difficult.

Nevertheless, based on the data gathered, it can be concluded that without the financial and social support provided by hunters, modern wildlife management in European countries would undoubtedly be very difficult. This social dimension is particularly important in Poland. This is connected with the way of pursuing game management, in which hunters who are members of hunting clubs belonging to the Polish Hunting Association administer the hunting grounds themselves, thus having a great influence on nature management and, in a broader dimension, on the functioning of rural areas as well.

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References

1. Mahoney, S.P.; Jackson, J.J. Enshrining hunting as a foundation for conservation—The North American Model. *Int. J. Environ. Stud.* **2013**, *70*, 448–459. [CrossRef]
2. Szpetkowski, K. Historia łowiectwa w Polsce. In *Łowiectwo*; Dzięciołowski, R., Flis, M., Eds.; Wydawnictwo Łowiec Polski: Warszawa, Poland, 2011; pp. 15–32.
3. Brainerd, S. *European Charter on Hunting and Biodiversity. Bern Convention*; Council of Europe: Strasbourg, France, 2007; p. 23.
4. Polish Hunting Law 1995. Available online: https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU19951470713/U/D19950713Lj.pdf (accessed on 16 September 2021).
5. Myronenko, M. *Analysis of Legislation and Practice of Hunting in Some EU Countries*. European Neighbourhood and Partnership Instrument. 2015, p. 91. Available online: http://awsassets.panda.org/downloads/analysis_of_legislation_and_practice_of_hunting_in_some_eu_countries.pdf (accessed on 29 October 2021).
6. Heberlein, T.A. *Navigating Environmental Attitudes*; Oxford University Press: New York, NY, USA, 2012; p. 228.
7. Wierzbicka, A.; Skorupski, M. What shapes public attitude toward hunting? *Studia Mater. CEPL Rogowie* **2017**, *50*, 20–25.
8. Varner, G.E. *Nature's Interests? Interests, Animal Rights, and Environmental Ethics*; Oxford University Press: New York, NY, USA, 2002; 164p.
9. Di Minin, E.; Clements, H.S.; Correia, R.A.; Capano, G.C.; Fink, C.; Haukka, A.; Hausmann, A.; Kulkarni, R.; Bradshaw, C. Consequences of recreational hunting for biodiversity conservation and livelihoods. *One Earth* **2021**, *4*, 238–253. [CrossRef]
10. Council Directive 2009/147/EC on the Conservation of Wild Birds or "Bird Directive". Available online: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0147 (accessed on 16 September 2021).
11. Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora, or "Habitats Directive". Available online: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:01992L0043-20070101 (accessed on 16 September 2021).
12. Borkowski, J. Polski system łowiectwa na tle rozwiązań europejskich. In *Problemy Współczesnego Łowiectwa w Polsce*; Gwiazdowicz, D.J., Ed.; Oficyna Wydawnicza G&P GOŚCIAŃSKI & PRĘTNICKI: Poznan, Poland, 2012; pp. 43–63.
13. Pillai, A.; Turner, A. *A Review of Game Bird Law and Licensing in Selected. European Countries. Scottish Natural Heritage Commissioned Report No. 942*; Great Glen House: Inverness, UK, 2017; p. 70.
14. Polish Hunting Association. Hunting Regulations. Available online: https://www.pzlow.pl/przepisy-prawne/statut-polskiego-zwiazku-lowieckiego/ (accessed on 16 September 2021).
15. Papińska, K. Hunting Management—Protection of Game. *Kontrola Państwowa* **2016**, *61*, 106–117.
16. Kościelniak-Marszał, M. Transformacja Polskiego Związku Łowieckiego w świetle ewolucji modelu łowiectwa w Polsce. *Studia Prawnoustr.* **2020**, *50*, 173–206.
17. FACE (European Federation of Associations for Hunting and Conservation). About Face. Available online: https://www.face.eu/about-face/ (accessed on 16 September 2021).
18. Middleton, A. *The Economics of Hunting in Europe. FACE Final Report*. 2014, p. 14. Available online: https://face.eu/sites/default/files/attachments/framework_for_assessing_the_economics_of_hunting_final_.en_.pdf (accessed on 29 October 2021).
19. Arnett, E.B.; Southwick, R. Economic and social benefits of hunting in North America. *Int. J. Environ. Stud.* **2015**, *72*, 1–12. [CrossRef]
20. ENETWILD Consortium; Vicente, J.; Plhal, R.; Blanco-Aguiar, J.A.; Sange, M.; Podgórski, T.; Petrovic, K.; Scandura, M.; Keuling, O.; Apollonio, M.; et al. Analysis of hunting statistics collection frameworks for wild boar across Europe and proposals for improving the harmonisation ofdata collection. *EFSA Supporting Publ.* **2018**, *15*, 1–33. [CrossRef]
21. FACE (European Federation of Associations for Hunting and Conservation). Members. Available online: https://www.face.eu/members/ (accessed on 16 September 2021).
22. Public and Corporate Economic Consultants (PACEC). *The Value of Shooting. The Economic, Environmental and Social Contribution of Shooting Sports to the UK*; PACEC: Cambridge, UK, 2014; p. 28.
23. BIPE–Cabinet de Conseil 2015. L'impact Économique et Social de la Chasse en France. Available online: https://www.fdc51.com/wp-content/uploads/2017/12/brochure_bipe1_etude_socioeco.pdf (accessed on 16 September 2021).
24. Deutsche Jagdverbande (DJV). Zahlen zu Jagd und Jägern. Mitgliederbefragung des DJV. 2016. Available online: https://www.jagdverband.de/zahlen-fakten/zahlen-zu-jagd-und-jaegern (accessed on 16 September 2021).
25. Andueza, A.; Lambarri, M.; Urda, V.; Prieto, I.; Villanueva, L.F.; Sánchez-García, C. *Evaluación del Impacto Económico y Social de la Caza en Castilla-La Mancha*; Fundación Artemisan: Ciudad Real, Spain, 2016; p. 76.
26. Bauer, J.; Herr, A. Hunting and fishing tourism. In *Wildlife Tourism, Impacts, Management and Planning*; Common Ground Publishing in Association with Cooperative Research Centre for Sustainable Tourism: Altona, Australia, 2004; pp. 57–78.

27. Martínez, J.; Viñuela, J.; Villafuerte, R. *Reconciling Gamebird Hunting and Biodiversity (REGHAB). Socio-Economic Aspects of Game-bird Hunting, Hunting Bags, and Assessment of the Status of Gamebird Populations in REGHAB Countries. Part 1: Socio-Economic and Cultural Aspects of Gamebird Hunting*; Ronda de Toledo s/n, 13005-Ciudad Real; Instituto de Investigación en Recursos Cinegéticos (IREC): Ciudad Real, Spain, 2002; p. 52.
28. Muposhi, V.K.; Gandiwa, E.; Bartels, P.; Makuza, S.M. Trophy hunting, conservation, and rural development in Zimbabwe: Issues, options, and implications. *Int. J. Biodivers* **2016**, *2016*, 763980. [CrossRef]
29. Martín-Delgado, L.M.; Rengifo-Gallego, J.I.; Sánchez-Martín, J.-M. Hunting Tourism as a Possible Development Tool in Protected Areas of Extremadura, Spain. *Land* **2020**, *9*, 86. [CrossRef]
30. *Statistical Yearbook of Forestry*; Statistics Poland GUS: Warszawa, Poland, 2020; p. 366.
31. Pérez-Bote, J.L.; Roso, R. Recreational Fisheries in Rural Regions of the South-Western Iberian. *Turk. J. Fish. Aquat. Sci.* **2014**, *1*, 135–143.
32. Kupren, K.; Czarkowski, T.K.; Hakuć-Błażowska, A.; Świszcz, B.; Rogulski, M.; Krygel, P. Socio-economic characteristics of anglers in selected counties of the Warmińsko-Mazurskie Voivodeship. *Studia Obsz. Wiej.* **2018**, *50*, 213–226. [CrossRef]
33. Deutsche Jagdverbande (DJV). Jäger in Europa. Available online: https://www.jagdverband.de/sites/default/files/2021-01/2021-01_Infografik_Jaeger_Europa_2020.jpg (accessed on 16 September 2021).
34. Pinet, J.M. *The Hunters in Europe. Report: Federation of Associations for Hunting and Conservation of the E.U.*; FACE, 1995; p. 12. Available online: https://www.kora.ch/malme/05_library/5_1_publications/P_and_Q/Pinet_1995_The_hunters_in_Europe.pdf (accessed on 29 October 2021).
35. FACE (European Federation of Associations for Hunting and Conservation). Hunters in Europe. 2010. Available online: http://www.face.eu/sites/default/files/attachments/data_huntersregion_sept_2010.pdf (accessed on 16 September 2021).
36. Heberlein, T.A.; Serup, B.; Ericsson, G. Female hunting participation in North merica and Europe. *Hum. Dimens. Wildl.* **2008**, *13*, 443–458. [CrossRef]
37. Massei, G.; Kindberg, J.; Licoppe, A.A.; Gačić, D.; Šprem, N.; Kamler, J.; Baubet, E.; Hohmann, U.; Monaco, A.; Ozolinš, J.; et al. Wild boar populations up, numbers of hunters down? A review of trends and implications for Europe. *Pest Manag. Sci.* **2015**, *71*, 492–500. [CrossRef] [PubMed]
38. Reimoser, F.; Reimoser, S. 2016 Long-term trends of hunting bags and wildlife populations in Central Europe. *Beiträge Jagd-Wildforschung* **2016**, *41*, 29–43.
39. Nö Jagdverband. Dem Wild Verpflichtet. Jahresbericht 2019. Available online: https://www.noejagdverband.at/wp-content/uploads/NOJ_JB2019_FG2.pdf (accessed on 16 September 2021).
40. Polish Hunting Association. Współczesne Postrzeganie Łowiectwa. Available online: https://www.jubileusz.ibles.pl/documents/10180/10948468/XZSL2018_Diana%20Piotrowska.pdf (accessed on 16 September 2021).
41. Polish Hunting Association. Jak Zostać Muśliwym? Available online: https://www.pzlow.pl/jak-zostac-mysliwym/ (accessed on 16 September 2021).
42. Pinet, J.M. *Les Chasseurs de France: Organisation, Typologie, Économie, Horizon 2000*; Union Nationale des Fédérations Départementales de Chasseurs: Paris, France, 1993; p. 103.
43. Kenward, R.; Sharp, R. Use Nationally of Wildlife Resources Across Europe. In *GEM-CON-BIO: Governance & Ecosystems Management for the Conservation of Biodiversity*; Wareham, UK, 2008; p. 18. Available online: https://cordis.europa.eu/project/id/28827 (accessed on 16 September 2021).
44. Eurostat. Wages and labour Costs. Available online: https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Wages_and_labour_costs (accessed on 16 September 2021).
45. Kordek, D. Wildlife management as a form of recreation in Warmia-Masurian Voivodeship at the Szczytno district as an example. Bachelor's Thesis, University of Warmia and Mazury, Olsztyn, Poland, 2018.
46. Czarkowski, T.K.; Wołos, A.; Kapusta, A. Socio-economic portrait of Polish anglers: Implications for recreational fisheries management in freshwater bodies. *Aquat. Living Resour.* **2021**, *34*, 19. [CrossRef]
47. Musso, F.; Cioppi, M.; Francioni, B. *Il Settore Armiero per uso Sportivo, Venatorio e Civile in Italia. Imprese Produttrici, Consumi per caccia e tiro, Impatto Economico e Occupazionale*; Franco Angeli: Milano, Italia, 2012; p. 288.

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Practical Village Planning Strategy of Different Types of Villages—A Case Study of 38 Villages in Shapingba District, Chongqing

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Abstract: Practical village planning is not only an important guide for implementing the rural revitalization strategy but also an important support for building a sustainable rural development model. The scientific measurement of rural development potential to effectively identify the future development direction and mode of rural areas is of great significance to realize the implementation of "hierarchical and key points" of village planning. Taking 38 villages in Shapingba District of Chongqing as the study area, this study comprehensively measures the rural development potential from four dimensions: location advantage, resource endowment, economic vitality, and development constraint. Results reveal the following: (1) the spatial distribution pattern of rural development potential in the study area is centered on the central and southern urban development area, gradually decreasing toward the peripheral area. The village development potential tends to be balanced overall, but differences are observed in advantage and development obstacles of villages in the district, and the four sub-dimensions show a large spatial heterogeneity;(2) the 38 administrative villages were divided into four types, namely, core planning area, important planning area, general planning area, and basic control area. Their percentages were 13.16%, 52.63%, 23.68%, and 10.53%, respectively; (3) differentiated planning contents and strategies for different types of areas are adopted to prepare well-detailed and clearly focused village plans to promote sustainable rural development.

Keywords: rural areas; village planning; potential assessment; village classification; planning strategy

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1. Introduction

As a traditional agricultural country, China still has approximately 600,000 administrative villages, which bear the development and change of agricultural production, rural life, rural landscape, and local culture [1]. Village planning is an important guarantee to guide rural development and construction, which is separated from village construction. The earliest village construction can be traced back to the rural reconstruction movement in the early 20th century when the concept of village planning was not clearly proposed [2]. Village planning was put on the agenda not until the reform and opening up and then gradually standardized. In 2008, the Urban–Rural Planning Law was promulgated. This law elevated the legal norms of rural planning to the level of the "basic law" of the country, established the legal status of the village planning system, and clarified its planning content, mainly including the village construction planning and the overall planning of village land use [3]. The former focused on the specific arrangement of village construction land layout, whereas the latter focused on land use control [4]. Although the contents of the two types of planning were related, they were different and were managed by different departments. Coordination between departments is lacking, making it difficult for traditional village planning to play a practical role by ignoring the different needs of different villages and adopting a "one-size-fits-all" planning approach in the planning process [5]. To strengthen the leading guidance role of village planning and to promote its implementation, in May 2019, the Ministry of Natural Resources issued the "Notice on Strengthening Village Planning for Rural Revitalization," which explicitly proposed to focus on the preparation of practical village planning with multiple rules and regulations. In this issue, village planning is required to tailor to local conditions, not be greedy for large and comprehensive, and promote the preparation of classification. Practical village planning is the detailed planning outside the boundaries for urban development. Moreover, practical village planning is the legal basis for carrying out national land use development and protection activities, implementing land space use control, issuing planning permits for urban and rural construction projects, and carrying out various constructions in the rural area. This planning has become an important public policy tool for guiding and regulating village construction and governance and an important regulatory tool for achieving sustainable rural development [6]. Under the background of establishing the territorial spatial planning system, village planning is not only a pioneering and basic work for implementing the rural revitalization strategy but also the most basic and microscopic planning unit for implementing the control of all elements of territorial spatial planning in rural areas [7].

Under the guidance of the rural revitalization strategy, the trickle-down effect of industry-feeding agriculture is gradually formed, which brings new development opportunities to the countryside [8]. The vast rural villages in China are undergoing drastic changes and transformations [9]. How exactly to support the implementation of rural revitalization strategy through practical village planning and realize a new pattern of rural construction with urban-rural integration has become an important issue for Chinese rural development. China has considerable villages with great regional differences, and the classification of practical village planning needs to be based on a scientific classification of village types. Therefore, the study of village classification is of great significance for village planning. As a research hotspot of rural geography, it has been of considerable concern to Chinese scholars [10,11]. They have mainly studied the reconstruction of rural settlements [12,13], the quality of rural settlement [14,15], rural resilience [16], and rural development potential [17–19]. Scholars in other countries have mainly conducted studies on rural evaluation based on rural geography and regional economic theories, and most of them are functionally oriented to classify rural areas into types. Among developed countries, British scholar Crook proposed to construct a rurality index based on rural geography, evaluated the rurality of England and Wales, and classified them into five types: extremely rural, moderately rural, moderately non-rural, extremely non-rural and urban [20]. Terry, M. outlined four ideal types of rural space based on the social resource heterogeneity of villages, namely, protected villages, competitive villages, patriarchal villages, and proxy villages [21]. Ian H. and Sarah M classified the countryside into tourism-protected, competitive, large-farm, and dependent countryside based on the performance of various characteristics of the countryside [22]. Among the less developed countries, Indian scholar Sharma R.L. measured the level of economic diversification in India based on the percentage of rural non-farm population and used it as a criterion to classify villages into four categories: very high economic diversification villages, high economic diversification villages, low economic diversification villages, and extremely low economic diversification villages [23]. It is increasingly focused on the improvement of rural living conditions and sustainable development, and the trend of multidisciplinary integration is gradually emerging [24]. With the enrichment of basic data and the rapid development of GIS and RS technologies, the village classification methods have gradually changed from qualitative description and field survey to evaluation model construction [25,26], spatial clustering [27,28], and others. To sum up, relevant research on village classification had a variety of perspectives and methods, but the research scale mostly focused on the county and town scales, which can serve for the micro-scale research with more practical guiding significance and need to be further discussed. On the basis of existing research, this study measures village development potential from four aspects, that is, location, resource, economy, and development constraint. The future development direction of villages is precisely identified and scientifically classified to provide a basis for the classification and promotion of practical village planning.

2. Data and Methods

2.1. Study Area

Shapingba District is located in the west of Chongqing (106°14′36″–106°31′35″ E, 29°27′13″–29°46′36″ N) (Figure 1). This district belongs to the parallel ridge and valley area of the east Sichuan basin, showing a combination of hills, terraces, and low mountains. The complex landform structure is the main reason for its internal administrative boundary and its irregularity. Its climate belongs to the subtropical monsoon humid climate zone. After the adjustment of the administrative jurisdiction in 2019, the area is approximately 276 km^2, with 22 towns (streets) and 49 administrative villages under its jurisdiction. The urbanization rate of the resident population is over 90%. In recent years, the urban expansion of Shapingba District has been rapid, and the rural space has been continuously squeezed. Considerable rural population flows into the city, and the problem of hollowing out of the countryside has become prominent. In the meanwhile, the deteriorating living conditions of rural houses and lagging infrastructure caused by early rapid urbanization have also constrained the development of the rural area.

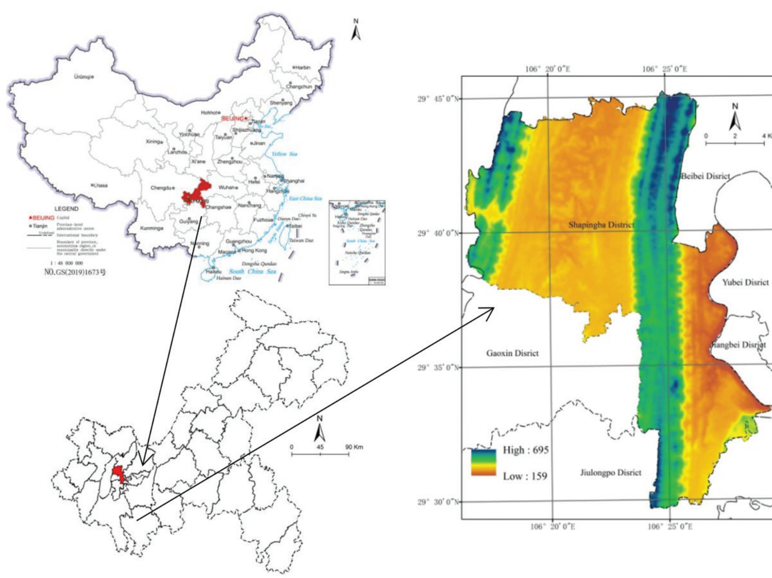

Figure 1. Study area.

2.2. Case Selection and Data Sources

2.2.1. Case Selection

According to the demand for the preparation of practical village planning, administrative villages with more than 80% of land requisitioned or included in the boundaries for urban development are not required to prepare a separate village plan. After excluding these two types of administrative villages, the administrative villages in Shapingba District that need to prepare planning include 38 administrative villages under the jurisdiction of nine towns (streets), which are the objects of evaluation in this study (Table 1).

Table 1. Administrative villages requiring planning in Shapingba District.

Town (Street)	Administrative Village under Jurisdiction
Fengwen street	Sanhe, Renhemen
Fenghuang town	Baziqiao, Fenghuangqiao, Hunanba, Weilingsi, Wufu, Yangjiamiao, Zaojueshu
Geleshan town	Geleshan, Jingang, Shandong, Tianchi, Xinkaishi
Huilongba town	Daqiao, Huilongba, Liangtanqiao, Qinglongmiao, Silong, Wuyunshan, Xixiqiao
Jingkou street	Jingkou, Nanxi, Shuangbei
Qingmuguan town	Guankou, Guanjiaqiao, Qingmuhu, Shinianqiao
Qinjiagang street	Lishuwan, Shangqiao, Xinqiao
Tuzhu town	Mingzhushan
Zhongliang town	Longquan, Maoshanxia, Qingfengshan, Shiyuan, Xinfa, Yongningsi

2.2.2. Data Sources

We have been cooperating with the Planning and Natural Resources Bureau of the Shapingba District for more than ten years on various projects, and have accumulated a large amount of data, which has laid a solid data foundation for this study. The data used in this study include spatial and attribute data. The spatial data come from three ways. The digital elevation model data (DEM, 30 m $\times$ 30 m) come from the Resources and Environmental Science Data Center (https://www.resdc.cn/, accessed on 25 September 2021). The township points come from Autonavi POI data (2019). Geological hazard data (2019), redlines for protecting the ecosystems data (2019), land acquisition data (2019), and land use vector data (2019) come from the Planning and Natural Resources Bureau of the Shapingba District. We extracted village-scale data, such as areas of the high-prone region of geological disaster, areas of redlines for protecting the ecosystems, areas of land acquisition, areas of cultivated land, areas of garden land, areas of construction land, and length of railway from them. We also calculated the total value of each administrative village using the ArcGIS zoning statistics module.

The attribute data come from field research and interviews. A total of 47 interviews were collected. The interviewees were the staff of township people's governments (sub-district offices) in nine towns (streets) and the village branch secretaries and relevant grass-roots staff in 38 administrative villages. We collected demographic data (total resident population, number of Communist Party members, number of migrant workers, number of people over 65 years old) and economic data (output value of primary, secondary, and tertiary industries and the area of machine-cultivated land) for each administrative village. We collected the number of township enterprises and family workshops including the number of natural and cultural landscape resources in each administrative village through the survey. For the few administrative villages with missing data, the data of the adjacent years were substituted.

2.3. Methods

2.3.1. Evaluation of Rural Development Potential

① Establishment of an index system

Rural development potential is a comprehensive reflection of the interaction of many factors, such as resource endowment, functional positioning, location conditions, development policies, and the historical background of each region [29]. Rural resources and their ability to use resources are of great significance to their development and revitalization [30,31]. Current studies on rural development potential are mostly focused on the potential for intensive rural land use [32], rural tourism development [33], and rural settlement improvement [34,35]. For the selection of indicators, this study extensively referred to the research literature related to rural evaluation. Zhang R.T. et al. selected three indicators of population development, industrial development and land use to construct the evaluation system of rural development level [36]. In the study of comprehensive evaluation and classification of rural development, Han X.Y. et al. selected seven categories of elements for evaluation, including agricultural production, non-farm economy, daily life, social management, facility services, natural conditions, and human resources, according to three major functions: living, production, and ecology [37]. In evaluating the characteristics of rural transformation, Long H.L. et al. constructed an evaluation system from three dimensions: rural economic development, agricultural production development, and rural social development [38]. The core elements of rural development potential evaluation through literature research should include location, resource conditions, and socio-economic development status. Rural development potential represents the ability to attract people, capital, and technology in the future. Therefore, the attraction of internal and external powers constitutes the main support of its development potential. The internal power is determined by the location of the village and its resource endowment. By contrast, external power refers to the support of external resources for rural development. This notion indicates that further opportunities for development resource elements can be obtained to accelerate the contribution of external resources to its construction, reflecting the industrial advantages of rural development and its ability to attract social capital. In addition, labor and productivity levels, including livelihood and production security and ecological security, pose obstacles to rural development. Such constraints are key factors affecting rural development potential.

The common indicators applicable to this study were sorted out by combing the relevant literature on village evaluation with high-frequency indicator screening. Then, through field research, individual indicators were screened out considering the objectives and characteristics of village development in Shapingba District. Finally, the evaluation index system of rural development potential including four dimensions and 18 specific indicators is established (Table 2). The indicators comprehensively reflect the rural development potential and conform to the principles of scientific method and operability. The indicators of location advantage measure the accessibility of villages to the outside world from the aspects of the average elevation, topographic relief, distance to the nearest township, and road network density. Resource endowment includes the connotation of natural and human resources. Thus, the indicators of per capita construction land area, per capita cultivated land area, per capita garden land area, the number of natural and cultural landscape resources, and the percentage of communist party members in the village are selected for characterization. Economic vitality is an important factor in attracting social capital and technology. We select indicators, such as the proportion of the output value of three types of industries, the number of township enterprises and family workshops, and the level of agricultural mechanization to characterize the development of village industrial structure and productivity level. The aging level of the population, the proportion of migrant workers in the total population, the proportion of the area of the high-prone region of geological disaster, and the proportion of redlines for protecting the area of the ecosystem in village area were selected to represent the degree of construction in village development. The consistency reliability (Cronbach's alpha) value of the rural development potential measurement index system established was tested to be 0.786, which is greater than the empirical threshold of 0.7 and meets the requirements of index representation and consistency.

Table 2. Evaluation index system of rural development potential.

Target	Indicators	Calculation Methods	Attribute	Entropy Weight Method	AHP	Final Weight
Location advantage	Average elevation (X1)	Calculated by ArcGIS zoning statistics module	-	0.0387	0.0418	0.0403
	Topographic relief (X2)	Maximum–minimum elevation	-	0.0287	0.0310	0.0299
	Distance to the nearest township (X3)	ArcGIS average nearest neighbor module statistics	-	0.0485	0.0524	0.0505
	Road network density (X4)	Length of railway/total area of the village	+	0.0692	0.0748	0.0720
Resource endowment	Per capita construction land area (X5)	Area of construction land/total village population	+	0.0630	0.0644	0.0638
	Per capita cultivated land area (X6)	Area of cultivated land/total village population	+	0.0576	0.0591	0.0584
	Per capita garden land area (X7)	Area of garden land/total village population	+	0.0420	0.0431	0.0424
	Number of natural and cultural landscape resources (X8)	Obtained from field research	+	0.0523	0.0537	0.0530
	Percentage of Communist Party members (X9)	Number of Communist Party members/total village population	+	0.0775	0.0795	0.0785
Economic vitality	Proportion of output value of primary industry (X10)	Output value of primary industry/gross value	+	0.0698	0.0641	0.0669
	Proportion of output value of secondary industry (X11)	Output value of secondary industry/gross value	+	0.1031	0.0919	0.0975
	Proportion of tertiary industry output value (X12)	Output value of tertiary industry/gross value	+	0.0540	0.0496	0.0518
	Number of township enterprises and family workshops (X13)	Obtained from field research	+	0.0475	0.0463	0.0469
	Level of agricultural mechanization (X14)	Area of machine-cultivated land/total cultivated land area	+	0.0525	0.0482	0.0503
Development constraint	Aging level of population (X15)	Number of people over 65 years old/total village population	-	0.0695	0.0711	0.0703
	Proportion of the area of the high-prone region of geological disaster (X16)	Area of the high-prone region of geological disaster/total area of the village	-	0.0296	0.0303	0.0299
	Proportion of migrant workers (X17)	Number of migrant workers/total village population	-	0.0574	0.0587	0.0581
	Proportion of the redlines for protecting the ecosystems area (X18)	Area of the redlines for protecting the ecosystems/total area of the village	-	0.0391	0.0400	0.0395

② Data standardization

Range standardization is a method to standardize positive and negative indicators in economic statistical analysis, which is a linear transformation of original data. The range is obtained by calculating the difference between the maximum and minimum values of the index. All index values are mapped to [0, 1]. The calculation formulas are as follows:

When X_{ij} is a positive indicator,

$$Z_{ij} = \frac{X_{ij} - \min X_{ij}}{\max X_{ij} - \min X_{ij}}, \quad (1)$$

when X_{ij} is a negative indicator,

$$Z_{ij} = \frac{\max X_{ij} - X_{ij}}{\max X_{ij} - \min X_{ij}}, \quad (2)$$

where Z_{ij} denotes the standard values for raw data, and X_{ij} denotes the specific index value of a sub-item.

③ Indicator weight set

The entropy weight method is an objective weighting method, which overcomes the subjectivity and randomness brought by the subjective weighting method. The application of the entropy weight method can make the evaluation result more in accord with the actual situation. To avoid the disadvantage of the insufficient scientific meaning of the weight results brought by objective assignment, we use Analytic Hierarchy Process to revise the weight results and comprehensively determine the weight. The steps are as follows:

First, the translation of dimensionless data is coordinated,

$$X\prime_{ij} = Z_{ij} + C, \tag{3}$$

where X'_{ij} is the index value after data standardization and translation, and C is the translation amplitude (in this study, $C = 0.0001$).

Second, the information entropy of the index is determined,

$$\mathrm{e_j} = -\left(\frac{1}{\ln \mathrm{n}}\right) \times \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{Z_{ij}} / \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{Z_{ij}} \ln\left(\mathrm{Z_{ij}} / \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{Z_{ij}}\right), \tag{4}$$

where e_j is the information entropy of the j-th evaluation index, and n is the number of evaluation units (n = 38 in this study).

Third, the index weight is determined,

$$Q_j = 1 - e_j / \sum_{j=1}^{m} (1 - e_j), \tag{5}$$

where Q_j is the weight of the j-th evaluation index, and m is the number of evaluation indexes (m = 18 in this study).

Finally, according to analytic hierarchy process, all indicators are divided into groups according to the correlation and affiliation. Each group is defined as a layer, and finally, a hierarchical system structure model associated with a combination of the highest, middle, and lowest layers is created (Figure 2). The consistent matrix method is used to compare the evaluation factors of the same layer from the second layer to compare their importance relative to the previous layer. Generally, the 1~9-bit scale method is used to construct the judgment matrix. The maximum characteristic roots and the corresponding eigenvectors of the above judgment matrix are calculated, and then the consistency of the matrix is tested using the consistency index, the average random consistency index and the consistency ratio. Referring to existing studies and consulting with experts, we constructed judgment matrices and past consistency tests [39]. The above steps are realized by YAAHP software to realize the calculation process. Then we obtain the weight F_i of each index. The indicator weights were revised using the preference coefficient μ to derive the final weight.

$$W_j = \mu F_i + (1 - \mu) Q_i, \tag{6}$$

where W_j is the final weight of the j-th evaluation index, and F_i is the weight calculated by Analytic Hierarchy Process. μ is the preference coefficient (μ = 0.5 in this study).

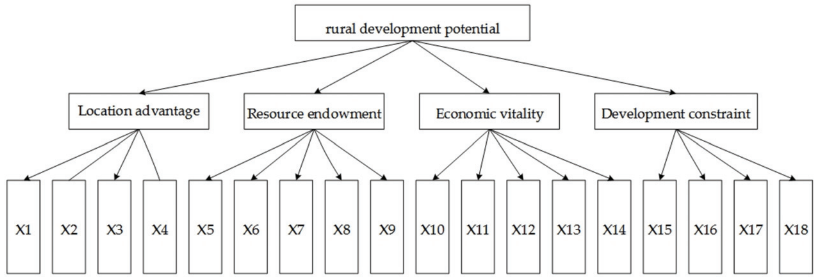

Figure 2. Hierarchical structural mode.

④ Evaluation model of rural development potential

Combined with the standardized value and weight of each evaluation index, the rural development potential in each evaluation unit is calculated. The calculation formula is as follows:

$$D_i = \sum_{j=1}^{m} W_j Z_{ij}, \quad (7)$$

where D_i is the score of the rural development potential.

2.3.2. Hierarchical Cluster

Cluster analysis is a method of classifying samples. The basic principle is to determine quantitatively the relationship between samples according to their attributes. The hierarchical cluster method is the most widely used clustering analysis at home and abroad. This method first regards the clustered samples or variables as a group, then determines the similarity statistics between classes, selects the closest two or several classes to merge into a new class, and calculates the similarity statistics between the new class and other classes. Then the closest two or several groups are selected to merge into a new class until all samples or variables are merged into one class. In this paper, the 38 administrative villages are taken as the basic units, and the research units are partitioned by hierarchical clustering. The specific steps of cluster analysis are as follows:

First, the Euclidean distance is selected to define the distance between samples:

$$d_{\mathrm{ij}} = \sqrt{\sum_{k=1}^{m} \left(X_{ik} - X_{jk} \right)^2}, \quad (8)$$

where d_{ij} is the distance between samples i and j, m presents the number of dimensions, and X_{ik} and X_{jk} are the evaluation values of samples i and j on the k-th dimension, respectively.

Then, the distance coefficient d_{ij} between any two sample points can be calculated in turn to obtain a distance matrix between samples:

$$\mathrm{D} = \left(d_{\mathrm{ij}} \right) = \begin{bmatrix} d_{11} & d_{12} & \ldots & \ldots & d_{1n} \\ d_{21} & d_{22} & \ldots & \ldots & d_{2n} \\ \ldots & \ldots & & \ldots & \ldots \\ d_{n1} & d_{n2} & \ldots & \ldots & d_{nn} \end{bmatrix}. \quad (9)$$

Finally, the longest distance method is used for clustering. If X_i is any sample in class $\mathrm{G_p}$ and X_j is any sample in class G_q, then the longest distance in classes G_p and G_q is as follows:

$$\mathrm{D}_{pq} = \max_{X_i \in G_p, X_j \in G_q} d_{ij}, \quad (10)$$

among them, the smaller the D_{pq} is, the smaller the distance between samples is. The closer the properties of samples i and j are, the more they can be divided into the same type.

3. Result and Analysis

3.1. Analysis of Rural Development Potential

3.1.1. Spatial Distribution Characteristics of Rural Development Potential

To clearly demonstrate the spatial distribution characteristics of rural development potential, the comprehensive scores obtained in Equation (7) were used. With Arcgis 10.2, the scores were spatially linked with each research unit in the form of vector data and partitioned using natural breaks [40]. We divided them into high, medium, and low levels and plotted the spatial distribution (Figure 3).

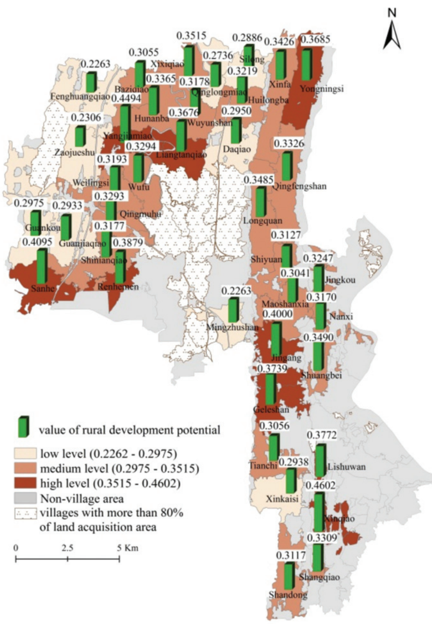

Figure 3. Spatial distribution of rural development potential in Shapingba District.

According to the calculation results, the average, minimum and maximum values of the rural comprehensive development potential are 0.2263, 0.3312, and 0.4602, and the proportion of the number of administrative villages in high, medium, and low levels is 13.16%, 73.68%, and 13.16%, respectively. Villages with medium development potential have a clear numerical advantage. The spatial distribution pattern of the rural development potential is centered on the central and southern urban development areas, gradually decreasing toward the peripheral area. The villages with a high potential value of rural development are mainly distributed in the south and central regions, whereas those with a low score are mainly concentrated in the northern fringe region. The overall development potential tends to be balanced, but the advantages and development obstacles of villages in different regions vary. The southern villages are close to the regional development center, with evident location advantages, a high degree of urban–rural development integration, and greater economic development vitality, which largely compensate for the disadvantage of the shortage of background resources and thus present good development potential. The northern center of the Shapingba District is the second core area of its urban development. With the strengthening of land acquisition, the urban area has been expanded, and the advantage and obstacles of village development at its edge are evident. In terms of development advantage, the villages in the region are rich in land resources and have a high number of natural and humanistic landscapes. The obstacle to development mainly comes from the strict control of redlines for protecting the ecosystems, making it difficult to meet the basic demand for construction land. The villages in the northern periphery are far away from the urban centers. The infrastructure construction is relatively backward, and the large influx of rural population into the cities has led to the phenomenon of the hollowing out of villages.

3.1.2. Characteristics Analysis on the Sub-Dimension

To better portray the spatial pattern of rural development potential in each sub-dimension and its divergent characteristics, we used the same method to divide the scores of each dimension into high, medium, and low levels and plotted the spatial distribution of the sub-dimension (Figure 4).

Figure 4. Distribution of rural development potential.

Location advantage (Figure 4a): On the whole, the location pattern of all villages is good, the average score of location advantage is 0.0967, and the proportion of the number of administrative villages in high, middle, and low levels is 39.47%, 42.11%, and 18.42%, respectively. The spatial distribution shows the trend of taking the north center as the core and gradually decreasing around. High-level areas are concentrated in the suburbs of the two town development centers in Shapingba District. The reason contains two aspects, one is that the area receives strong radiation from the urban transportation network, has good road facilities, and has good external connection conditions; the other is that 69% of the villages in the high-level area have a gentle average elevation and topographic relief, making village construction less difficult, which is also a key reason for its good performance in terms of coordination of location pattern. The medium-level villages are located on the periphery of the high-level ones, with the largest number of villages and slightly poorer external connections. The low-level areas are mainly located at the edge of Shapingba District, mainly because of the weak external communication due to the underdeveloped transportation network.

Resource endowment (Figure 4b): Its average score was 0.0528, with significant village differences, and the proportion of the number of administrative villages in high, medium, and low levels is 13.16%, 36.84%, and 50.00%, respectively. Spatially, the distribution trend of "high value in the north and low value in the south" is observed. The high-level areas are scattered in a dotted pattern in the south of the district. These villages have abundant land resources and good resources and conditions for tourism development. The medium-level villages are mainly distributed in a contiguous manner in the northern part of the region. The villages in the low-level areas are mainly located in the southern district. Considering their proximity to the town centers, land urbanization is developing rapidly. The loss of cultivated and garden land is serious, and the agricultural production capacity is low.

Economic vitality (Figure 4c): Its average score was 0.0351, and the proportion of the number of administrative villages in high, medium, and low levels is 15.78%, 42.11%, and 42.11%, respectively. The spatial distribution shows a trend of decreasing from south to north. All of the high-level areas are located in the southern part of Shapingba District, where rural enterprises are well developed, and the location advantage of being close to the urban makes them closely connected to the needs of urban residents and the development of urban industries. The industrial structure is dominated by the secondary and tertiary industries. The medium-level areas are mainly distributed in the northern part of the region. The villages in the low-level area are mainly located in the southern fringe area, where the poor foundation of industrial development and low productivity and organization levels are important development obstacles in the area.

Development constraints (Figure 4d): The higher the score of this dimension, the smaller the resistance to the spatial development of the village. Its average score was 0.1466, and the proportion of the number of administrative villages in high, medium, and low levels is 34.21%, 44.74%, and 21.05%, respectively. The spatial distribution is most widely distributed in the high and medium-level areas. The two main reasons are as follows: (1) population loss is relatively small; and (2) ecological control is moderate, and relatively free space is available for development.

3.2. Classification of Village Types

The spatial clustering function of SPSS Statistics 26 software was used to realize the calculation process of Equations (8)–(10) and output the system clustering results. Based on the clustering results, a total of 38 administrative villages in the district were divided into four types, namely, core planning area, important planning area, general planning area, and basic control area. The spatial visualization results were realized using ArcGIS 10.2 (Figure 5).

(1) Core planning area: The village type has five administrative villages, that is, Sanhe, Renhemen, Yangjiamiao, Xinfa, and Yongningsi. These villages have excellent geographical locations, mostly located in suburban integration areas or township centers.

They have evident advantages in the four sub-dimensions and have great potential for comprehensive rural development. They should have priority in the rural revitalization strategy in order to develop as a regional growth hub. They must also lead the surrounding villages to develop together. The villages in the core planning area should be given the highest level of attention and detail in the preparation of practical village planning to support of their scientific and orderly development.

(2) Important planning area: This area includes 20 administrative villages, such as Mingzhushan, Qingmuhu, Xinqiao, Lishuwan, and Nanxi. The villages in the important planning area are the highest proportion of the four types, and their comprehensive rural development potential is second only to that of the Core Planning Area, with some dimensions scoring even higher. The development of such villages aims to expand the impact of the strengths dimension while compensating for the weaknesses of development. Therefore, their village planning should be sufficiently oriented.

(3) General planning area: This area includes nine administrative villages, such as Huilongba, Guankou, Silong, Daqiao, and Shiyuan. Compared with the first two types, their comprehensive development potential is lower because of two main reasons. First, these villages are mostly located in mountainous areas with high altitudes and undulating terrain, which translates to high construction costs. Second, these villages involve a wider area of redlines for protecting the ecosystems, and the production and living are more restrictive. Therefore, the preparation of village planning in general planning areas should pay more attention to the balance between ecological protection and village development, and prevent the behavior of obtaining economic benefits at the expense of ecological environment through the strict control of village planning.

(4) Basic control area. This area includes four administrative villages, namely, Maoshanxia, Xinkaisi, Zaojueshu, and Fenghuangqiao. The villages in the basic control area have the worst performance in terms of comprehensive development potential and can be implemented as the lowest level of detail in the village plan. The implementation of land use control of the master planning is used as the main basis for village construction and development.

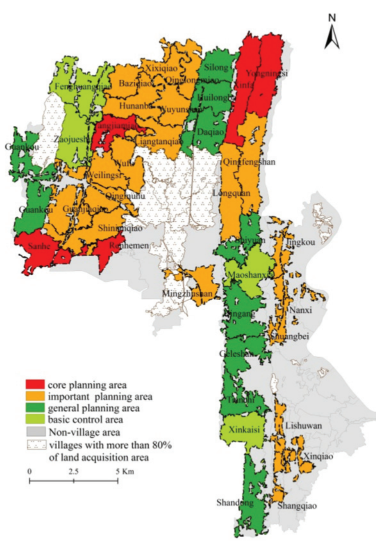

Figure 5. Results of village type.

4. Differentiation Strategies for Practical Village Preparation

According to the positioning of villages and the actual needs of national space development and protection, the level of the development potential of villages should be considered, and the preparation requirement of practical village planning must be reasonably determined. Combined with the requirements of the latest technical specifications for the preparation of practical village planning in Chongqing, the planning requirements should include nine items: development orientation and objectives, territorial space control and layout, industrial development layout, rural residential area planning, infrastructure and basic public service facilities layout, ecological protection and land consolidation, historical and cultural preservation and heritage planning, rural style guide, safety and disaster prevention and mitigation planning (Table 3). However, these requirements are not mandatory for all village plans, and each village can choose the necessary contents and expanded contents in a scientific and reasonable way according to its development type and need, where the former is mandatory for the village plan, whereas the latter is selected in conjunction with the actual needs of the village. According to the basic requirements of the technical specifications, the first two planning requirements shall be necessary for all villages, and the rest shall be selected according to different types of villages. This paper classifies the villages into four types: core planning area, important planning area, general planning area, and basic control area, based on the level of rural development potential. With reference to the current content selection of village planning in Chongqing, this paper identifies the necessary and expanded planning content for different types of villages and proposes corresponding planning strategies based on the authors' field project experience. The level of detail required by the four types of village planning varies, and the corresponding plan content should also make a difference. To clearly demonstrate the study, we selected one case village in each of the four types for illustration. The case villages were Sanhe, Qingfengshan, Shiyuan, and Maoshanxia (Figure 6). The village plans shown in Figure 6 are all projects undertaken by our research team in 2019.

4.1. Core Planning Area

The core planning area is in the urban–rural transition zone, receiving stronger radiation from urban resources, and generally has the advantages and potential to become a back garden of the city. This area also has the conditions to transform into a city. To a certain extent, the core planning area has the ability to serve urban development, undertake urban function spillover, and meet urban consumption demand [41,42]. This area is the front-runner of urban–rural integration development. In terms of the level of detail, the core planning area has the highest requirements for the content of the practical village plan, which should meet the nine requirements. In terms of planning strategies, we use the land layout planning of Sanhe Village as an example (Figure 6a). First, priority is given to guaranteeing the demand for land for the construction of public service facilities, such as education, culture, and medical care, improving their construction level and service quality, forming a public service network with villages in the core planning area as the central nodes, and improving the attractiveness of the countryside. Second, the construction of a railway network is focused to deepen regional connections, to attract external resources into the countryside, and to help rural revitalization. Third, this planning also focuses on improving the efficiency of rural construction land use, effectively developing unused land, and stimulating rural development while safeguarding land for the development of rural advantageous industries.

Table 3. Contents of practical village planning.

No.	Planning Contents	Village Types Core Planning Area	 Important Planning Area	 General Planning Area	 Basic Control Area
1	Development orientation and objectives	⊙	⊙	⊙	⊙
2	Territorial land control and layout	⊙	⊙	⊙	⊙
3	Industrial development layout	⊙	⊙	⊙	○
4	Rural residential area planning	⊙	⊙	○	○
5	Infrastructure and basic public service facilities layout	⊙	⊙	○	○
6	Ecological protection and land consolidation	⊙	⊙	⊙	○
7	Historical and cultural preservation and heritage planning	⊙	⊙	○	○
8	Rural style guide	⊙	○	○	○
9	Safety and disaster prevention and mitigation planning	⊙	○	○	○

Note: ⊙ Necessary content ○ Expanded content.

4.2. Important Planning Area

The important planning area is the main area to support district development and the area to guarantee ecological security. The latest functional positioning of Chongqing has positioned the rural area of Shapingba District as the "Western International Slow City" and the "Beautiful Back Garden for Citizens' Leisure". Vigorously developing modern urban agriculture in urban suburbs will become the main direction of agricultural and rural reform in the Shapingba District and the important direction of its village planning. The village planning of the important planning area includes seven necessary contents. In terms of planning strategies, we take the village of Qingfengshan Village as an example (Figure 6b). First, we can plan and implement high-quality projects for leisure agriculture and rural tourism and build a number of leisure and tourism parks with complete facilities and diverse functions, forest homes, recreation bases, rural bed and breakfast, and small towns with special features. Second, to form a development model integrating humanities and ecology into cultural tourism, we consider the following: inheriting local culture, identifying the core cultural elements of rural regional space, discovering cultural tourism resources with uniqueness and attractiveness, using traditional villages, scientific and technological agriculture, idyllic scenery, agricultural production landscape, green ecological resources, and other elements. Third, we aim to deeply improve road networks, water and drainage networks, power grids, and communication networks, including other infrastructure construction to provide a good development environment for industries in the district.

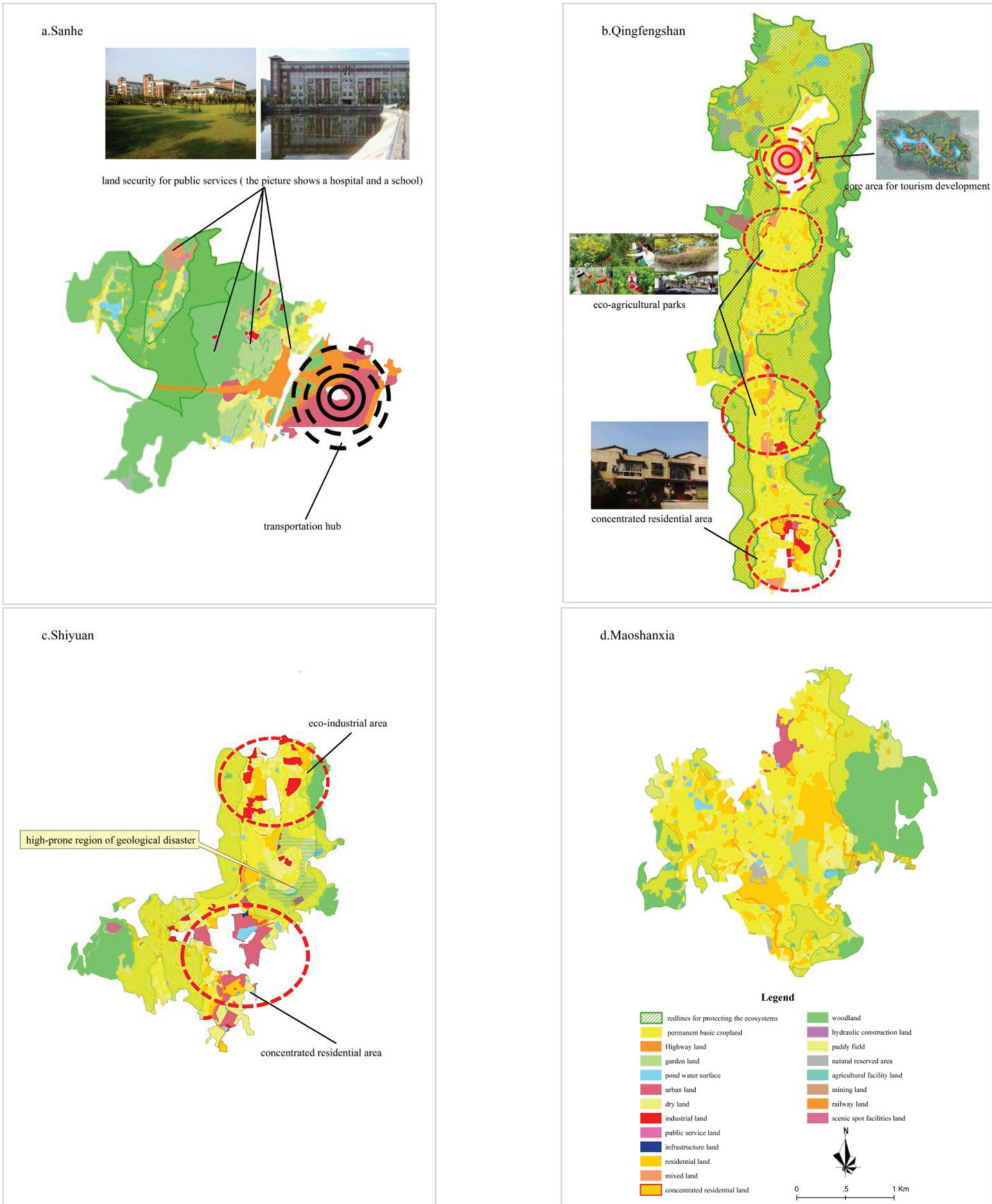

Figure 6. Land use layout planning for different types of villages.

4.3. General Planning Area

The general planning area is a key area for ecological protection, and the necessary content of its village planning should contain four basic contents, namely, development orientation and objectives, national land control and layout, industrial development layout, and ecological protection and land consolidation. In terms of planning strategies, we take the village of Shiyuan Village as an example (Figure 6c). First, we strengthen the protection of ecological land, guide the gradual withdrawal of environment-consuming industries, and develop ecological industries. Second, we focus on ecological safety restoration and reduce the adverse impact of geological disasters on the production and life of villagers. Third, a certain percentage of construction land is reserved for mobile indicators to support scattered rural cultural and tourism facilities and new rural industries.

4.4. Basic Control Area

The background conditions and economic development environment of the basic control area are relatively backward, and its village planning requires the lowest level of detail. The necessary content only needs to cover two items, that is, development orientation and objectives, and national land control and layout. Taking Maoshanxia Village as an example (Figure 6d), in terms of planning strategy, the first point is to strictly implement spatial use control and strictly control the phenomenon of illegal land use. The second one is to inherit vernacular culture, including vernacular landscapes, humanistic and historical relics, and traditional farming implements, and to protect traditional vernacular architecture and prevent major demolition and construction. Finally, efforts should be made to enhance the infrastructure construction in farmers' clusters, improve the efficiency of public services, and meet the basic needs of residents for water, electricity, transportation, and communication.

5. Discussion

A village is the basic unit of social and economic activities in rural China and is the basis for guaranteeing the ecological security of land and maintaining the harmonious relationship between man and land [43,44]. Owing to China's early implementation of the development strategy of "industry and city first," the relationship between urban and rural areas presents evident "dual" characteristics [45]. The development of China's rural areas has shown great imbalance and inadequacy [46], and the problems of rural environmental pollution, lagging public service facilities, and disorderly village construction have become more prominent. In the international arena, rural decay is also an area of research focus [47]. After experiencing urbanization and reverse urbanization, developed countries have taken a series of measures to narrow the urban-rural gap and promote rural development, such as the "New Town Construction" in the United States [48] and the suburban rural development plan in France [49]. However, rural revitalization is not a revitalization of all existing villages but rather targeted support for development. Based on the real situation of village areas, this paper establishes a scientific index system to measure their development potential in four dimensions: location advantage, resource endowment, economic vitality and development limitation, and uses them as a basis for classifying types to guide the hierarchical implementation of village planning. We can solve the problem of inadequate rural development with more pertinence only by scientifically identifying village types and using limited financial and material resources where they are really needed. Starting from the practical problems faced by rural decline, this study comprehensively considers the current situation, direction and law of rural development, and constructs a set of scientific and reasonable evaluation index systems. On the one hand, we hope that its evaluation results can be used as an important basis for judging the development potential of villages and for identifying and analyzing the problems and shortcomings of village development. On the other hand, it is applied to guide local village planning practice, improving local government service management, and providing a reference for the scientific and reasonable formulation of optimal strategies for rural revitalization. This study provides a new idea and path for the revitalization of the world's villages and further enriches the research content of rural geography.

China's vast territory and the large geographical differences in the physical geography of different regions, including the spatial patterns and constraints of urban and rural development in each region, also determine the diversity and complexity of rural types [50]. This study analyzes and discusses the rural types in the southwestern hilly mountainous areas and does not cover other areas, such as highlands and plains. In addition, considering the limitation of basic data and research scale, this study did not regard rural areas from the perspective of long-term series, and the constructed index system also has room for further improvement. Subsequent studies will further optimize the classification method of rural potential types, refine the evaluation index system, consider the stage changes of rural development from the perspective of long-term series, and further explore the rich connotation of rural development potential to optimize the zoning results.

6. Conclusions

The spatial distribution pattern of rural development potential in the study area is centered on the central and southern urban development areas, gradually decreasing toward the peripheral areas. Villages with higher potential values are mainly located in the south and central parts of the district, whereas those with lower scores are mainly clustered in the northern fringe of Shapingba District. In the four sub-dimensions, a significant pattern of regional differentiation was observed. Based on the comprehensive development potential of villages, a total of 38 administrative villages in the district are divided into four types, namely, core planning area, important planning area, general planning area, and basic control area, with the proportion of the four types of areas being 13.16%, 52.63%, 23.68%, and 10.53%, respectively. Based on the completed village planning projects, our group draws experience from practical work, clarifies the development characteristics and directions of different types of villages, and implements differentiated development strategies. In village planning, the villages are divided by development potential. The different types of villages should contain different planning contents. The core planning area with the highest village development potential should contain the most comprehensive planning contents, and the village planning of the important planning area, the general planning area and the basic control area have gradually decreased in detail, in order to realize the effective gathering and optimization of elements and promote the orderly development of villages.

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References

1. Smith, N.R. *The End of the Village: Planning the Urbanization of Rural China*; University of Minnesota Press: Minneapolis, MN., USA, 2021; pp. 45–46.
2. An, G.H.; Zhang, E.D. *Village Planning and Management*; The Chinese Press: Beijing, China, 2009; p. 42.
3. Chen, X.H.; Lü, H. The rural spatial planning Under the construction of territorial spatial planning system—Take Jiangsu as an example. *Urban Plan. Forum.* **2021**, *261*, 74–81. [CrossRef]
4. Ji, G.Q. Spatial allocation of land resources under the guidance of regional industrial integration. *China Land.* **2020**, *419*, 47–49. [CrossRef]
5. Li, H.; Wang, L.J. The inefficiency of land allocation and its optimization. *China Land Sci.* **2015**, *29*, 63–72. [CrossRef]

6. Zhou, J.J.; Hua, C.; Wu, S.S.; Wang, Z.R.; Wang, X.K. Sustainable village planning indicator system in rural transformation: Application to Xufu Village in the Yangtze River Delta Region in China. *J. Urban Plan. Dev.* **2021**, *147*, 05021050. [CrossRef]
7. Ai, Y.H.; Dong, W.; Wu, S.; Gao, X. Study on village construction land scale under the territorial spatial planning system. *Dev. Small Cities Towns.* **2021**, *39*, 24–31. [CrossRef]
8. Wen, Q.; Zheng, D.Y. Identification and revitalization of rural poverty-stricken areas in northwest China. *Geogr. Res.* **2019**, *38*, 509–521. [CrossRef]
9. Cohen, B. Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technol. Soc.* **2006**, *28*, 63–80. [CrossRef]
10. Meng, H.H.; Li, T.S.; Yu, Z.S.; Li, F. Rurality and a correlation analysis of the county economy in Anhui province. *Econ. Geogr.* **2018**, *33*, 144–148. [CrossRef]
11. Guo, X.D.; Ma, L.B.; Zhang, Q.Y. The spatial distribution characteristics and the basic types of rural settlement in loess hilly area: Taking Qin'an county of Gansu province as a case. *Sci. Geogr.* **2013**, *33*, 45–51. [CrossRef]
12. Li, J.; Lo, K.; Zhang, P.Y.; Guo, M. Reclaiming small to fill large: A novel approach to rural residential land consolidation in China. *Land Use Policy* **2021**, *109*, 105706. [CrossRef]
13. Zhong, J.; Liu, S.Q.; Huang, M.; Cao, S.; Yu, H. Driving forces for the spatial reconstruction of rural settlements in mountainous areas based on structural equation models: A case study in western China. *Land* **2021**, *10*, 913. [CrossRef]
14. Wang, P.Y.; Qin, X.F.; Li, Y.R. Satisfaction evaluation of rural human settlements in northwest China: Method and application. *Land* **2021**, *10*, 813. [CrossRef]
15. Hu, Q.Y.; Wang, C. Quality evaluation and division of regional types of rural human settlements in China. *Habitat Int.* **2020**, *105*, 102278. [CrossRef]
16. Zhou, J.Z.; Hou, Q.H. Resilience assessment and planning of suburban rural settlements based on complex network. *Sustain. Prod. Consump.* **2021**, *28*, 1645–1662. [CrossRef]
17. He, J.; Jin, X.H.; Liang, X.Y.; Zhao, Q.L.; Han, B.; Xiao, Y.; Wu, X.H.; Hu, J.; Zhou, Y.K. Research of rural system development potential in Huaihai Economic Zone: A case study of Northern Jiangsu province under the background of urban-rural integration. *J. Nat. Resour.* **2020**, *35*, 1940–1957. [CrossRef]
18. Qiao, L.Y. Village type identification and rural revitalization strategy: A case study of Zhangzi County of Shanxi Province. *Prog. Geogr.* **2019**, *38*, 1340–1348. [CrossRef]
19. Bai, B.G.; Chen, F.G.; Zhou, G. Functions of village classification based on POI data and social practice in rural revitalization. *Arab. J. Geosci.* **2021**, *14*, 1690. [CrossRef]
20. Wang, D.; Liu, Z.Y. Progress and implications of international rural space research. *Prog. Geogr.* **2019**, *38*, 1991–2002. [CrossRef]
21. Terry, M. New rural territories: Regulating the differentiated rural spaces. *J. Rural Stud.* **1998**, *14*, 107–117. [CrossRef]
22. Ian, H.; Sarah, M. The economic diversity of rural England: Stylised fallacies and uncertain evidence. *J. Rural Stud.* **2003**, *20*, 263–272. [CrossRef]
23. Megha, C.; Sangeeta, C.; Roshan, L.R.; Sharma, G.L. A report on management of national rural employment guarantee scheme issues and challenges, Lbsim, Delhi. *Metamorph. A J. Manag. Res.* **2011**, *10*, 56–57. [CrossRef]
24. Paffarini, C.; Torquati, B.; Tempesta, T.; Venanzi, S.; Vecchiato, D. Rural sustainability and food choice: The effect of territorial characteristics on the consumers' preferences for organic lentils. *Agric. Food Econ.* **2021**, *9*, 29. [CrossRef]
25. Chen, Q.G.; Zhang, J.; Yang, L.N. GIS description of the Chinese ecotone between farming and animal husbandry. *J. Lanzhou Univ.* **2007**, *43*, 24–28. [CrossRef]
26. Liu, J.H.; Gao, J.X.; Lv, S.H.; Han, Y.W.; Nie, Y.H. Shifting farming-pastoral ecotone in China under climate and land use changes. *J. Arid Environ.* **2011**, *75*, 298–308. [CrossRef]
27. Li, S.J.; Sun, Z.G.; Tan, M.H.; Guo, L.L.; Zhang, X.B. Changing patterns in farming–pastoral ecotones in China between 1990 and 2010. *Ecol. Indic.* **2018**, *89*, 110–117. [CrossRef]
28. Shi, W.J.; Liu, Y.T.; Shi, X.L. Contributions of climate change to the boundary shifts in the farming-pastoral ecotone in northern China since 1970. *Agric. Syst.* **2018**, *161*, 16–27. [CrossRef]
29. Zhou, Y.; Guo, Y.Z.; Liu, Y.S. Areal types and their development paths in rural China. *Geogr. Res.* **2019**, *38*, 467. [CrossRef]
30. Li, Y.; Liu, Y.; Long, H.; Cui, W. Community-based rural residential land consolidation and allocation can help to revitalize hollowed villages in traditional agricultural areas of China: Evidence from Dancheng County, Henan Province. *Land Use Policy* **2014**, *39*, 188–198. [CrossRef]
31. Chen, W.Q.; Dai, Y.Q.; Geng, Y.W.; Gao, H.; Ma, Y.H. A method for village classification based on POI data and gravity model. *Trans. Chin. Soc. Agric. Mach.* **2020**, *51*, 202–211. [CrossRef]
32. Wang, Y.; Zhai, T.T.; Yin, D.Y. Evaluation of land consolidation potential of vacant villages under back-ground of rural revitalization: Taking Wulian County of Shandong province as an example. *Bull. Soil Water Conserv.* **2019**, *39*, 288–292. [CrossRef]
33. Wang, X.Y.; Zhu, W.L. Study on the identification of poverty-stricken areas and the development potential of rural tour-ism in Shandong Province. *Chin. J. Agric. Resour. Reg. Plan.* **2018**, *39*, 269–275.
34. Tu, S.S.; Long, H.L.; Liu, Y.Q.; Li, T.T. Research progress and prospects in the methodology of assessing the potential of rural residential land consolidation. *J. Nat. Resources* **2015**, *30*, 1956–1968. [CrossRef]

35. Liu, J.; Jin, X.B.; Fan, Y.T.; Xiang, X.M.; Ran, N.; Zhou, Y.K.; Shen, C.Z. Rural residential land consolidation strategy from a perspective synthesizing towns, villages and land parcels: A case study in Xinyi city, Jiangsu province. *Geogr. Res.* **2018**, *37*, 678–694. [CrossRef]
36. Zhang, R.T.; Zhang, X.L.; Lu, J.F. Evaluation and spatiotemporal differentiation of rural development in the Yangtze River Delta, China. *J. Ecol. Rural. Environ.* **2021**, *37*, 698–705. [CrossRef]
37. Han, X.Y.; Yan, F.Y. Research on the comprehensive evaluation and types recognition of rural development under rural revitalization. *China Popul. Resour. Environ.* **2019**, *29*, 156–165. [CrossRef]
38. Long, D.P.; Li, T.S.; Yu, Z.S.; Meng, H.H. Assessment of rural development level and mechanism analysis based on micro perspective—A case study of the demonstration area of urban-rural intergration in Gaoling county of Shaanxi Province. *Econ. Geogr.* **2013**, *33*, 115–121. [CrossRef]
39. Qi, Y.N.; Wang, L. Application of AHP-entropy weight method in hazards susceptibility assessment in mountain town. *Bull. Surv. Mapp.* **2021**, *6*, 112–116. [CrossRef]
40. Tang, G.A.; Yang, X. *ArcGIS Geographic Information System Spatial Analysis Experiment Course*; Science Press: Beijing, China, 2006.
41. Hong, W.; Liu, K.W.; Xue, X.P. Comprehensive potential evaluation of rural revitalization of urban-rural intergration in the western provinces, China. *J. Earth Sci. Environ.* **2021**, *43*, 735–743. [CrossRef]
42. Zhao, M.; Fang, C.H.; Chen, C. Re-theorizing and accessing integrated urban-rural development: An empirical study on China's megacities. *Urban Plan. Forum* **2018**, *242*, 11–18. [CrossRef]
43. Li, Y.R.; Fan, P.C.; Liu, Y.S. What makes better village development in traditional agricultural areas of China? Evidence from long-term observation of typical villages. *Habitat Int.* **2019**, *83*, 111–124. [CrossRef]
44. Tu, S.S.; Long, H.l.; Zhang, Y.N.; Zhou, X.Y. Process and driving factors of rural restructuring in typical villages. *Acta Geogr. Sin.* **2019**, *74*, 323–339. [CrossRef]
45. Liu, Y.S.; Hu, Z.C.; Li, Y.H. Process and cause of urban-rural development transformation in the Bohai Rim Region, China. *J. Geogr. Sci.* **2014**, *24*, 1147–1160. [CrossRef]
46. Gao, Y.Y.; Zheng, J.H.; Bu, M.L. Rural-urban income gap and agricultural growth in China: An empirical study on the provincial panel data, 1978–2010. *China Agr. Econ. Rev.* **2014**, *6*, 92–107. [CrossRef]
47. Markey, S.; Halseth, G.; Manson, D. Challenging the inevitability of rural decline: Advancing the policy of place in northern British Columbia. *J. Rural Stud.* **2008**, *24*, 409–421. [CrossRef]
48. Zasada, I.; Weltin, M.; Reutter, M.; Verburg, P.H.; Piorr, A. EU's rural development policy at the regional level-are expenditures for natural capital linked with territorial needs? *Land Use Policy* **2018**, *77*, 344–353. [CrossRef]
49. Pavel, C.; Fatmir, G.; Miroslava, R.; Dusan, D.; Sergio, G.P. Land fragmentation and production diversification: A case study from rural Albania. *Land Use Policy* **2018**, *76*, 589–599. [CrossRef]
50. Li, Y.R.; Bu, C.L.; Cao, Z.; Liu, X.H.; Liu, Y.S. Village classification system for rural vitalization strategy: Method and empirical study. *J. Nat. Resour.* **2020**, *35*, 243–256. [CrossRef]

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Article

A Spatial Typography of Environmentally Friendly Common Agricultural Policy Support Relevant to European Green Deal Objectives

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Abstract: The European Union (EU), through its implementation of the Common Agricultural Policy (CAP), is increasingly emphasising the development of environmentally friendly forms of agriculture. This is confirmed by, for example, the new European Green Deal (EGD). In Poland, the most important forms of CAP support for the environmentally friendly management of agricultural land were the following measures: agri-environment-climate measures (AECM) and organic farming (OF). These aid instruments facilitated the use of a range of packages and variants, which resulted in the pro-environmental forms of support offered by the CAP support having a very diverse internal structure. This study therefore attempts to synthesise the diversity of CAP financial support using spatial typology methods. The researched support measures were divided into three basic directions for developing agriculture: ecology, environment and habitat. The research procedure involved the D'Hondt method, the normalisation method, standardisation and correlation. The study was conducted on the example of Poland, and the basic territorial unit of analysis was the commune. It was shown that support for environmentally friendly activities in Poland related to almost 10% of the total farm area. The utilised agricultural area (UAA) covered by subsidies can be broken down as follows: organic farming—32.7%, environmental farming—31.8%, habitat farming—35.5%. The detailed results of the typology indicate the complexity of the spatial distribution of environmentally friendly CAP funds, which is defined by environmental determinants and the characteristics of the farms themselves. Farm-specific, non-environmental determinants were found to be the most significant, including farm size and managerial expertise.

Keywords: agri-environment-climate measures; organic farming; sustainable development; typology; CAP; Poland

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1. Introduction

Implementing sustainable agricultural development requires a compromise between agricultural producers, who mainly aim to maximise outputs, and societal interests, among which care for the environment is growing in importance. Under the conditions of the Common Agricultural Policy (CAP), this is leading to a redefinition of the concept of agriculture, from the typical production approach to the holistic, sustainable and rational management of natural resources that are considered to be public goods subject to special protection [1,2].

This approach prioritises climate change mitigation, making the maintenance of extensive and biodiverse agricultural systems more important than the production (market) outputs of agriculture [3,4]. This justifies the expenditure of EU funds to support environmentally friendly activities in agriculture [5–7]. However, some studies to date have indicated that the current mechanism of EU payments in this area does not always guarantee that the assumed environmentally friendly changes will happen [8,9].

The issue of sustainable agriculture development also occupied an important place in the European Commission's communication on the European Green Deal (EGD) published in December 2019—a new growth strategy that aims to transform the EU into a just, prosperous society, living in a modern, resource-efficient and competitive economy [10]. Implementing this plan will require that several green challenges be tackled (e.g., achieving net zero greenhouse gas emissions by 2050) to modernise the social and economic systems of Member States [11].

Particularly large changes will be required in agriculture, as evidenced by the future CAP's premise that as much as 40% of total funds will be allocated to supporting climate-related goals [12]. In this respect, it is of key importance to implement the "Farm to Fork" strategy, which assumes, among other aspects, particularly strong support for areas used for organic farming, such that, by 2030, they constitute 25% of the agricultural land area [13–15]. This percentage compared to the area of organic farms in Poland and their small share in the total utilised agricultural area (about 3.0%) necessitates major scientific work (including spatial studies of agriculture). This indicates the need to develop a new, environmentally friendly model of agriculture that increasingly makes agriculture a sphere for producing environmental public goods [16,17].

It is assumed that implementing the EGD will be a major impetus for the development of Polish agriculture, which is distinguished by its predominance of small family farms (averaging c. 10 ha) and agricultural production that is often extensively used and preserves biodiversity [18].

The authors agree with Pe're et al. [19] that it is necessary to search for new, more appropriate tools that can reliably assess initiatives undertaken to rationally manage natural resources in the agricultural sector [20]. The typology drawn up in this work (using an appropriate methodology) is part of the search for and development of appropriate instruments for assessing the implementation of environmentally friendly CAP measures.

Two CAP instruments implemented in Poland under the Rural Development Programme for 2014-20 (RDP 2014-20), i.e., the agri-environment–climate measure (AECM) and organic farming (OF), were adopted as the basis for this targeted research. They are a continuation of similar payments being implemented since Poland's accession to the EU, i.e., the years 2004-06 and 2007-13. Their formal and legal characteristics are detailed in the relevant ordinances of the Minister of Agriculture and Rural Development [21,22]. The above green measures are part of the trend towards sustainable development, as they contribute to promoting practices designed to protect: soil; water and climate; valuable natural habitats and endangered species of birds; landscape diversity; and endangered genetic resources of crops and animals [23]. They constitute an important financial instrument for encouraging farmers to apply practices leading to the greening of agricultural production. Farmers receive financial resources as remuneration for undertaking specific actions in support of the natural environment as compensation for any potential loss in income in transitioning from intensive to extensive farming [24,25]. The analysed RDP instruments encourage farmers to act to protect the environment and biodiversity and to preserve the landscape, thereby raising their environmental awareness.

Because AECM and OF goals have not been universally achieved—especially within the scope discussed in this article—further research is needed to answer difficult questions. This applies both to the search for optimal solutions based on a catalogue of good agricultural practices and to scientific evidence. Farmer et al. [26] noted that research is needed that addresses the spatial correlation between the implementation of the agri-environment–climate measure (AECM; including organic farming) and environmental indicators at large spatial scales, to elucidate the impact of Agri-environmental payments on ecological targets. This points to a current research gap in the assessment of the rationality of spending CAP funds on green forms of agriculture, especially in the context of the natural predispositions of a given area. In connection with the above, the authors propose to extend the traditional spatial analysis of farmland covered by CAP payments (concerning individual measures, packages, variants) with a synthetic approach based on a tripartite division, involving support for three basic types of agriculture: ecological, environmental and habitat. This division is the basis for the spatial typology developed by the authors, which aims to systematise the various types of support offered under the CAP.

The main objective of the present research is to spatially delimit the selected types of environmentally friendly subsidies and to assess them in terms of the impact of environmental conditions and selected agricultural characteristics. This targeted analysis is also a preliminary part of wider research that aims to identify the mechanism shaping the spatial distribution of land covered by environmentally friendly CAP subsidies, which is the basis for inferring how to potentially increase their share in the total area of agricultural land, in line with the premises of the EGD.

2. Materials and Methods

2.1. Scope and Data

The study is limited to two measures of RDP 2014-20, namely AECM and OF, which were spatially analysed based on their total coverage of nearly 1.285 million hectares of utilised agricultural area (UAA). These comprise a complex system of pro-environmental payments covering seven basic categories (packages) and including 40 various forms of payment (variants, schemes; see Appendix A).

To simplify this complex system in a way that reflected the specifics of the individual measures (packages), the subsidised UAA areas were expertly divided by the type of agriculture supported, i.e.,

- organic farming (O)—one package: the RDP 2014–20 measure;
- environmental farming (E)—four AECM packages in total: sustainable agriculture; protection of soils and waters; preservation of traditional orchards; preservation of endangered plant genetic resources in agriculture;
- habitat farming (H)—two AECM packages in total: valuable habitats and endangered bird species in Natura 2000 areas; valuable habitats outside Natura 2000 areas.

The proposed division approximates the level of greening of farming, which results from the requirements that the packages impose on farmers. The intensity of activities is reflected in the subsidy rates, the highest being for organic farming and the lowest for the sustainable agriculture package.

The determined spatial systems were assessed using a range of diagnostic attributes aggregated into two groups of conditions: environmental determinants and agricultural characteristics. On this basis, we attempted to answer the question: does a tract of farmland's coverage by pro-environmental payments result from its environmental conditions or from the nature of the agricultural activity?

The study covers the territory of Poland, according to its system of 16 provinces (tabular presentation) subdivided into a total of 2477 communities (Pol. *gmina*) (cartographic presentation). Spatial analysis was based on the 2282 communities in which there was land subsidised by the various green measures (in 195 communities, no financial support from these measures was recorded).

The timeframe related to the CAP 2014-20 financial framework. Given that pro-environmental payments and commitments are long-term in nature (generally 5 years), the analysis was based on long-term average areas of subsidised land (AECM—2015-20; OF—2017-20).

The source material used comprised public data from the Local Data Bank of Statistics Poland (LDB)(Pol. *BDL GUS*) in Warsaw (PSR 2010) and the Institute of Soil Science and Plant (Pol. *IUNiG*) in Puławy (for environmental conditions) and data provided by the Agency for Restructuring and Modernisation of Agriculture (ARMA)—the disburser of CAP funds in Poland.

2.2. Methods

The study primarily employed two methods.

The first was to normalise the diagnostic attributes and present them as averaged values (the Perkal index) [27,28]. This entailed a synthetic approach to environmental determinants and selected agricultural characteristics. Calculations were made according to the formula:

$$Z_{ji} = \frac{(X_{ji} - avg.X_i)}{\delta_i}, \quad (1)$$

where: Z_{ji}—normalised value of diagnostic feature "i" in spatial unit "j"; X_{ji}—value of diagnostic feature "i" in spatial unit "j"; $avg.X_i$—mean value of diagnostic feature "i"; δ_i —standard deviation of diagnostic feature "i".

The baseline values (national averages) of the indices so constructed were used as the basis for the spatial delimitation of values. In the cartographic presentation—assuming a threshold of ± 0.5 of a standard deviation (δ)—four classes were distinguished, while in the statistical analyses (see tables), the indices for spatial units were generalised into two groups: above the national average (↑) and below (↓).

The second method was the D'Hondt method [29], which allows any structure to be objectively examined [30,31]. The method is practically applied, among others, to distributing seats in the electoral systems of many countries [32]. In this case, it consists, in essence, of dividing each absolute value or percentage assigned to O, E and H by the integers 1 to 6, producing a set of 18 quotients. Then, the six largest quotients are selected from this set. Next, each tested element (O, E and H) is assigned a weighting corresponding directly numerically to how many of these six largest quotients belong to it (i.e., if one of the six largest quotients belongs to O, O is weighted as 1, etc.). The analysed distributions were spatially delimited based on this weighting, conventionally reflecting the share of a given element as: 1—very low, 2—low, 3—significant, 4—high, 5—very high, 6—total dominance in the distribution. The predominant number of quotients was adopted as the criterion, and the number of quotients was aggregated into two groups (of 1, 2, 3, 4 quotients, and of 5 and 6 quotients), and this was used as the basis of the spatial typology of the breakdown of subsidised land by type of pro-environmental payments. This division into two groups of quotient numbers highlighted areas with the highest shares of a given type of support. Attempts to use a larger number of quotient groups (e.g., first group—1 and 2 quotients; second group—3 and 4 quotients; third group—5 and 6 quotients) significantly increased the number of sub-types, thereby worsening the readability and making spatial interpretation difficult.

The discussed method was used mainly for its modifiability (aggregation into a system of two groups) and the clarity of interpretation of results, i.e., the identification and characterisation of individual types. The typology was based on an a posterioriapproach that consists of distinguishing typological classes and identifying types [33].

The research also used Pearson's linear correlation coefficient (r). This made it possible to assess the strength and direction of the relationship between the structure and the level of support for the researched measures and the determinants of the green development of agriculture in Poland.

2.3. Identification of Determinants: Planes for the Evaluation of Pro-Environmental Payments

To more fully interpret the spatial differentiation of farmland covered by pro-environmental payments, diagnostic attributes were distinguished that were expressed as average normalised values and then used as the basis for assessing the environmental determinants and the level of selected characteristics of farms.

Environmental determinants were analysed using three diagnostic attributes, i.e.,

- less favoured areas (LFA), as % of total area (according to ARMA, as of 2019);
- protected areas, as % of total area (according to BDL GUS, as of 2019);
- soils of the lowest soil quality classes (V, VI), as % of UAA (according to IUNiG, as of 2010).

In addition to environmental determinants, the research also attempted to assess the impact of selected non-environmental characteristics. Despite the numerous determinants featured in the literature (level of socio-economic development, state agropolitics, sales markets, level of urbanisation) [34], this was done using only the following three diagnostic farm characteristics:

- average farm area (according to ARMA): because payment sizes depend on UAA, this is an important financial stimulus in the adoption of agri-environmental obligations.
- share of farm managers with higher education (according to PSR 2010): educational level affects the level of ecological awareness, and is relevant to green activities in agriculture.
- level of land productivity (total agricultural production in PLN per 1 ha of UAA): a determinant of the extensification of agricultural production. Land productivity was calculated by multiplying the areas of specific crops by the 2010 Standard Output (SO) coefficient. Standard Output is calculated by Poland's Institute of Agricultural and Food Economics National Research Institute (*Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej—Państwowy Instytut Badawczy*) as the 5-year average of production per hectare of crop in regional average production conditions.

Furthermore, it should be emphasised that the spatial differentiation of the characteristics taken into account is a result of economic history and dates back to the 18th century [35]. At that time, Poland underwent what is referred to as the three 'Partitions', which involved the loss of rule to Russia, Prussia and Austria, as a result of which the area of Poland was shrinking gradually until the Polish state ceased to exist altogether after the third Partition. The more than 120 years of foreign rule resulted in the socio-economic polarisation of Polish territory. The divides between the eastern, western and southern parts of the Polish territory were so deep, strong and conspicuous that they are still perceivable today, such as in the structure of agriculture and agricultural practices [36].

3. Results

3.1. Determinants of Green Agricultural Development in Poland

The quality of the natural environment was assumed to determine the intensity and direction of development of a green agricultural management system. Support may provide a special alternative to the traditional (high-productivity) approach of farms in less favoured areas (that often have lower productivity), including those with poor-quality soils. On the other hand, the introduction of environmentally friendly agricultural practices should be particularly important in areas of high natural value containing legally protected areas.

The analysis showed that the three diagnostic attributes (see Section 2.3) determined the environmental determinants index, which stands out as being highly spatial and regionally differentiated (from −0.46 in Lower Silesia Province and −0.49 in Opole Province to 0.47 in Lubusz Province—see Table 1), and above all in the distribution of communities (see Figure 1a). The level of environmental determinants (index below −0.50) was low in 832 communities (33.6% of the total) usually located within the borders of the provinces of Lower Silesia and Lublin. Conversely, the index was high (above 0.50, indicating a significant agricultural predisposition to environmentally friendly activities) in 621 communities (25.1% of the total), which were most numerous in the provinces of Central Poland—Łódź and Masovia (see Figure 1a).

The agricultural characteristics index exhibited a similarly strong spatial differentiation (see Figure 1b).There were 163 communities (6.6% of total) with a low index (below −0.50), with the most being in the provinces of Lesser Poland, Masovia and Greater Poland. By contrast, the 0.50 threshold was exceeded (i.e., high index values), indicating favourable agricultural determinants, in 523 communities (21.1% of the total) concentrated in three provinces of Northern and Western Poland: Lower Silesia, Warmia-Masuria and West Pomerania (see Figure 1b).

Table 1. Selected determinants of green development of Polish agriculture.

No.	Spatial Unit	Environmental Conditions				Agricultural Conditions			
		Diagnostic Attributes				Diagnostic ATTRIBUTES			
		Less Favoured Areas (LFA), as % of Total Area	Protected Areas, as % of Total Area	Soils of Lowest Soil Quality Classes (V, VI), as % of UAA	Synthetic Index	Average Farm Area	Farms Run by Farmers with Higher Education, as % of Total	Land Productivity (Global Agricultural Production per 1 ha of UAA—A Destimulant)	Synthetic Index
	National total	54.7	32.6	32.4	0.00	10.8	10.3	5.6	0.00
1	Lower Silesia	33.0	18.6	20.0	−0.46	16.5	11.9	4.5	0.36
2	Kuyavia-Pomerania	39.0	32.4	20.8	−0.27	16.9	9.7	6.8	0.03
3	Lublin	38.8	22.7	22.4	−0.35	8.0	11.4	5.3	0.01
4	Lubusz	93.9	38.4	41.2	0.47	21.1	12.0	4.2	0.53
5	Łódź	57.9	19.5	46.7	0.07	8.1	9.5	6.8	−0.24
6	Lesser Poland	36.6	53.0	30.4	0.05	4.3	8.2	5.1	−0.28
7	Masovia	65.4	29.7	44.4	0.20	9.2	10.5	6.5	−0.12
8	Opole	15.1	27.6	21.1	−0.49	18.9	9.2	5.8	0.16
9	Subcarpathia	40.3	44.9	28.5	−0.03	4.8	9.6	3.8	−0.06
10	Podlasie	91.6	31.6	41.1	0.38	12.9	11.9	5.3	0.18
11	Pomerania	55.5	32.9	30.3	−0.02	19.4	11.2	4.8	0.38
12	Silesia	30.6	22.0	42.0	−0.16	7.9	10.4	5.7	−0.09
13	Holy Cross	40.0	65.0	38.4	0.30	6.0	10.1	5.4	−0.14
14	Warmia-Masuria	76.5	46.7	22.4	0.18	22.8	13.5	4.3	0.65
15	Greater Poland	53.5	31.6	37.4	0.05	14.7	9.0	7.9	−0.16
16	West Pomerania	69.9	21.8	25.6	−0.09	30.7	15.6	4.2	1.01

Source: own study based on data from LDB and IUNiG.

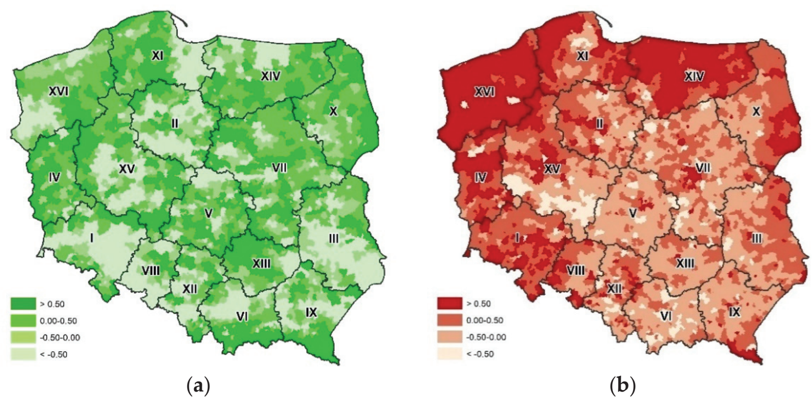


Figure 1. Environmental (**a**) and agricultural (**b**) determinants of green development of Polish agriculture. Voivodships are marked with digits: I—Lower Silesia, II—Kuyavia-Pomerania, III—Lublin, IV—Lubusz, V—Łódź, VI—Lesser Poland, VII—Masovia, VIII—Opole, IX—Subcarpathia, X—Podlasie, XI—Pomerania, XII—Silesia, XIII—Holy Cross, XIV—Warmia-Masuria, XV—Greater Poland, XVI—West Pomerania. Source: own elaboration.

Of the 2282 surveyed communities receiving pro-environmental subsidies, only 252 (11.0%) had high levels of both environmental determinants and the selected agricultural characteristics. These areas are particularly predestined for the development of green management methods. By contrast, only 153 communities (6.7%) had low scores.

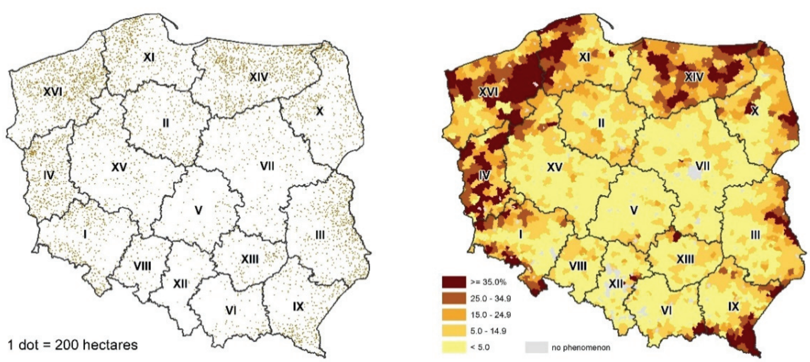
3.2. Farmlands Subsidised for Implementing the Pro-Environmental Obligations of RDP 2014-20

Analysis of the ARMA data showed that, on average, 1.2849 million hectares per year were covered by green activities (AECM and OF—total) (see Table 2; Figure 2a). Land covered by pro-environmental support amounted to 9.2% of the total area of agricultural holdings, which is low compared to the leading EU countries in this respect (e.g., in Germany, the area subsidised by the agri-environmental programme is nearly 5.3 million ha, i.e., around one quarter of total UAA [37]).

Table 2. Forms of green support for agriculture in Poland: level, structure and determinants.

No.	Spatial Unit	Subsidised Land		Including Structure by Support Type							
				Organic Farming—O		Environmental Farming—E		Habitat Farming—H		Sequence	
		ha (Thousands) *	as % of Farms	%	Quotient	%	Quotient	%	Quotient	Type	Subtype
	National total	1284.9	9.2	32.7	2	31.8	2	35.5	2	ES	ES
	of which, by province										
1	Lower Silesia	80.9	9.6	27.2	2	25.2	1	47.6	3	H	H.2
2	Kuyavia-Pomerania	69.0	6.7	8.1	0	80.3	6	11.7	0	E	E.1
3	Lublin	120.9	8.9	22.3	1	46.7	3	31.0	2	E	E.2
4	Lubusz	100.2	24.6	33.1	2	14.7	1	52.2	3	H	H.2
5	Łódź	21.1	2.3	28.6	2	54.5	3	17.0	1	E	E.2
6	Lesser Poland	19.9	4.1	35.0	2	15.9	1	49.1	3	H	H.2
7	Masovia	58.2	3.3	35.2	2	33.4	2	31.4	2	ES	ES
8	Opole	17.2	3.4	9.0	0	77.6	5	13.5	1	E	E.1
9	Subcarpathia	64.7	12.0	15.3	1	10.3	0	74.4	5	H	H.1
10	Podlasie	104.1	10.2	46.7	3	13.9	1	39.4	2	E	O.2
11	Pomerania	111.1	15.4	16.2	1	58.8	4	25.0	1	E	E.2
12	Silesia	10.5	3.2	16.9	1	46.0	3	37.2	2	E	E.2
13	Holy Cross	26.1	5.3	28.4	2	46.1	3	25.5	1	E	E.2
14	Warmia-Masuria	204.3	21.2	55.0	3	16.4	1	28.6	2	E	O.2
15	Greater Poland	76.6	4.5	14.7	1	54.8	3	30.5	2	E	E.2
16	West Pomerania	200.0	23.8	44.1	3	17.7	1	38.2	2	E	O.2
	of which, assumed determinants										
↓	environmental	410.5	5.7	24.0	1	49.7	3	26.3	2	E	E.2
↑		874.4	13.0	36.8	2	23.4	1	39.8	3	H	H.2
	correl. coeff.	x	0.165	0.299	x	0.122	x	−0.319	x	x	x
↓	agricultural	285.4	4.6	23.0	1	42.4	3	34.6	2	E	E.2
↑		999.5	12.8	35.5	2	28.8	2	35.7	2	ES	ES
	correl. coeff.	x	0.397	0.346	x	0.057	x	−0.173	x	x	x

* groups of communities: ↓—below national average (unfavourable), ↑—above national average (favourable). Source: own study based on data from ARMA and LDB.



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

Figure 2. Area of land covered by pro-environmental RDP support (**a**), and its share in total UAA of farms (**b**).Source: own elaboration.

This percentage, which indicates the territorial significance of green activities in agriculture, is highly spatially diversified. At the regional level, it ranges from 2.3% in Łódź Province to over 20.0% in Lubusz (24.6%), Warmia-Masuria (21.2%) and West Pomerania (23.8%; see Table 2).

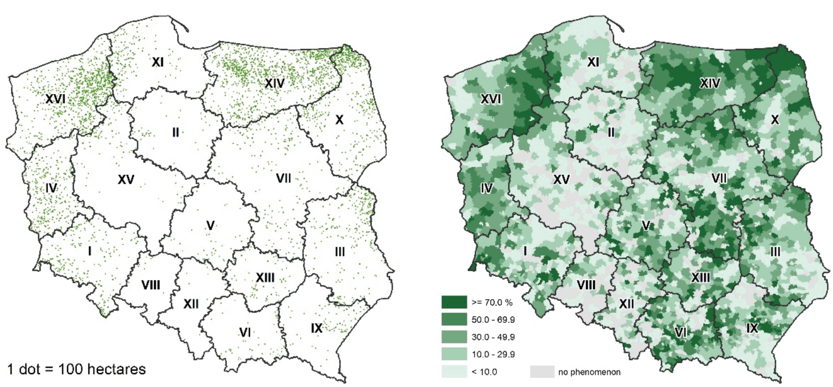
According to communities, the variation in the percentages of land covered by pro-environmental support ranges from less than 3% in 886 units (including by the least, at less than 0.1% in 22 communities) to over 15.0% in 439 communities and over 35% in 150 communities (see Figure 2b).

The spatial distribution of the analysed farmlands was evaluated as correlating poorly with environmental conditions (r = 0.165). A significant difference in the proportion of land receiving support from pro-environmental measures was also confirmed to exist between communities with unfavourable (↓ 5.7%) and favourable (↑ 13.0%) environmental conditions. There was a much stronger relationship between land covered by pro-environmental support (in table: subsidised land as % of farms and agricultural determinants (a synthetic indicator derived from diagnostic attributes: average farm area; farms run by farmers with higher education, as % of total; land productivity)) (r = 0.397). This indicates that the nature of the farm itself (acreage, productivity) and the education of its manager play a significant role in the use of environmentally friendly farming methods.

3.3. Breakdown of Farmland by Type of Pro-Environmental RDP Payments

The analysis also addresses the problem of the spatial differentiation of the selected types of payments. In accordance with the adopted methodology, the analysis included the average annual area for the period 2015-19, which results from agri-environmental payments being made as five-year commitments. The subsidised land was shown to be highly spatially differentiated, which we will discuss for each subsidy type separately.

In the case of organic farming, payments relate to two main forms (payments during conversion and post-conversion), under which different rates have been distinguished, as well as a number of subsidy types (agricultural, vegetable, herb, orchard, berry, fodder and permanent pasture; see Appendix A). In total, the above payments coveredc.420,400 ha (of which 77.3% relates to post-conversion payments), which was strongly differentiated regionally, fromc.1500 ha in Opole Province toc.112,300 ha in Warmia-Masuria. At the commune level, the largest area of organic farming subsidies, exceeding 5000 ha, was recorded in two communities in West Pomerania (BiałyBór and Szczecinek—eachc.5800 ha)—and in the commune of Gołdap in Warmia-Masuria Province (c.6800 ha; see Figure 3a).



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

Figure 3. Area of land subsidised for organic farming in ha (**a**), and its share in total area of land covered by pro-environmental RDP support (**b**). Source: own elaboration.

Subsidies for organic farming account for 32.7% of the total land area of farms receiving pro-environmental support from RDP 2014–20. The analogous percentage at the province level ranges from less than 10.0% in Kuyavia-Pomerania and Opole to 55.0% in Warmia-Masuria (see Table 2). It is also heavily spatially differentiated at the commune level (see Figure 3b). A significant group of communities (483 communities) distinguished by the dominance (over 50%) of organic farming in the total area covered by pro-environmental RDP payments is worthy of attention. There were also 26 communities where pro-environmental payments included only subsidies for organic farming (100%).

Considering the disproportionate share of land subsidised for organic farming in light of the division of communities by environmental determinants (↓ 24.0%, ↑ 36.8%) and agricultural characteristics (↓ 23.0%, ↑ 35.5%), we find that the spatial distribution of such areas depends slightly more on agricultural characteristics (r = 0.346) than on environmental conditions (r = 0.299; see Table 2).

Looking at the analysed pro-environmental payments, the "environmental agriculture" category was also distinguished, with four agri-environmental and climate action packages supporting environmental protection and biodiversity in agriculture, i.e.,

- sustainable agriculture: total in Polandc.268,100 ha (fromc.800 ha in Lesser Poland up toc.47,400 ha in Kuyavia-Pomerania) (see Figure 4a);

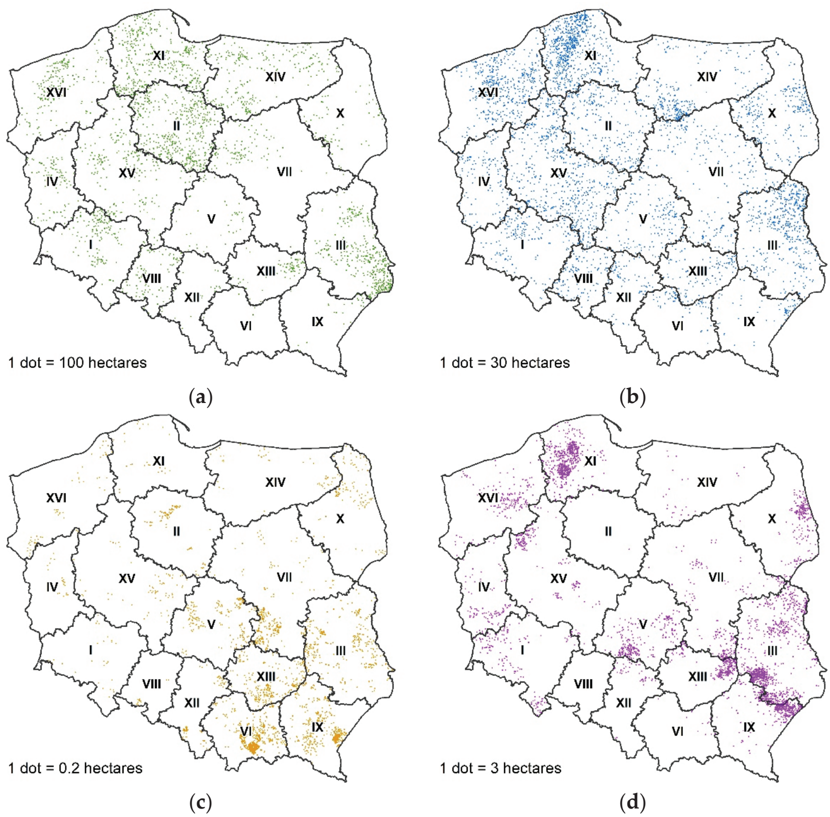


Figure 4. Land subsidised to support environmental agriculture, in ha (**a**)—sustainable agriculture, (**b**)—protection of soils and waters, (**c**)—preservation of orchards with traditional varieties of fruit trees, (**d**)—preservation of endangered plant genetic resources in agriculture).Source: own elaboration.

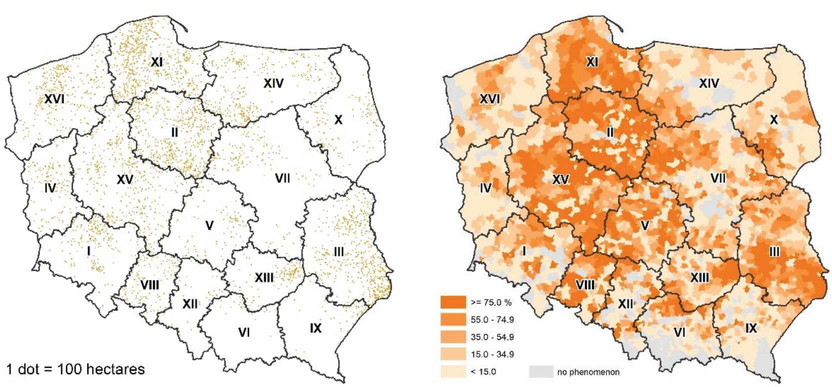
- protection of soils and waters: totalc.129,000 ha (from 2100–2200 ha in the provinces of Lesser Poland, Subcarpathia and Silesia up toc.22,200 ha in Pomerania) (see Figure 4b);
- preservation of traditional tree orchards: 565 ha in total (from 3 ha in Opole Province to 134 ha in Lesser Poland) (see Figure 4c);
- preservation of endangered plant genetic resources in agriculture: a total of c.11,000 ha (from zero in Opole Province toc.2800 ha in Lublin Province) (see Figure 4d).

Total payments under the category of "environmental agriculture" related to c.408,600 ha—from c.3200 ha in Lesser Poland up to c.65,400 ha in Pomerania (by commune, 3000–3400 ha in Czarna Dąbrówka in Pomerania, Dołhobyczów in Lublin Province and Kozłów in Warmia-Masuria; see Table 3, Figure 5a). In the total area covered by pro-environmental payments, these represent 31.8%. This percentage is heavily spatially and regionally differentiated (Table 3) and at the commune level (Figure 5b).

Table 3. Pro-environmental forms of CAP support: distribution of subsidised land by support type (100% = 2282 communities).

Type	Subtype	No.	Number of Communities	%	Delimitation of Structures of Pro-Environmental CAP Support *		
					Organic—O	Environmental—E	Habitat—H
Organic farming—O (486 communities)	O.1	1	117	5.1	6	0	0
		2	62	2.7	5	1	0
		3	73	3.2	5	0	1
	O.2	4	54	2.4	4	2	0
		5	37	1.6	4	1	1
		6	67	2.9	4	0	2
		7	34	1.5	3	1	2
		8	42	1.8	3	2	1
Environmental agriculture—E (946 communities)	E.1	9	472	20.7	0	6	0
		10	92	4.0	0	5	1
		11	131	5.7	1	5	0
	E.2	12	61	2.7	0	4	2
		13	36	1.6	1	4	1
		14	78	3.4	2	4	0
		15	39	1.7	1	3	2
		16	37	1.6	2	3	1
Habitat farming—H (631 communities)	H.1	17	260	11.4	0	0	6
		18	101	4.4	1	0	5
		19	57	2.5	0	1	5
	H.2	20	35	1.5	0	2	4
		21	74	3.2	2	0	4
		22	33	1.4	1	1	4
		23	34	1.5	1	2	3
		24	37	1.6	2	1	3
Equal share of directions—ES (219 communities)		25	42	1.8	0	3	3
		26	62	2.7	3	3	0
		27	81	3.5	3	0	3
		28	34	1.5	2	2	2

* Number of quotients (see Section 2). Source: own study based on data from ARMA and LDB.



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

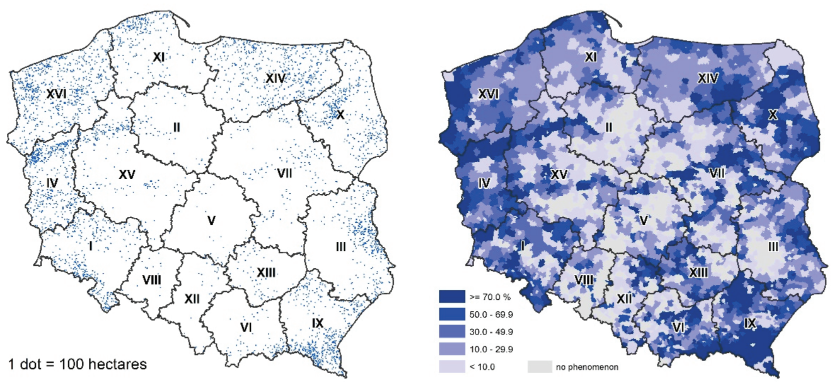
Figure 5. Area of land subsidised with support for environmental agriculture (**a**), and its share in the total area covered by pro-environmental RDP support (**b**). Source: own elaboration.

The assessment of this spatial distribution showed significant differences between the identified groups of determinants—environmental (↓ 49.7%, ↑ 23.4%) and agricultural (↓ 42.4%, ↑ 28.8%). However, these relationships were not confirmed by analysis of the correlation coefficients (Table 2).

The research also distinguished the category of "habitat farming", in whichthe second largest determinant of pro-environmental subsidies (after the farmer's environmental awareness) is the presence of valuable natural habitats within the boundaries of the farm. This targeted analysis covered two AECM 2014-20 packages, i.e.,

- valuable bird habitats and endangered bird species in Natura 2000 areas: total ofc.258,700 ha (fromc.600 ha in Silesia Province andc.900 ha in Opole Province toc.52,400 ha in Western Pomerania);
- valuable habitats outside Natura 2000 areas: total ofc.197,200 ha (fromc.1500 in Opole Province toc.34,100 ha in Warmia-Masuria).

Support for habitat farming covered a total of 455,900 ha. This area is highly regionally diversified—from c.2300 ha in Opole Province to c.76,400 ha in West Pomerania Province. In the system of communities, the largest areas were recorded as c.5000 ha in Komańcza (Subcarpathia), c.5300 ha in Słońsk (Lubusz Province) and c.5700 ha in Trzcianne(Podlasie Province) (see Figure 6a).



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

Figure 6. Area of land subsidised with support for habitat farming, in ha (**a**), and its share in the total area covered by pro-environmental RDP support (**b**). Source: own elaboration.

The CAP funds allocated to the support of farms with valuable natural habitats constitute, on average, 35.5% of the total pro-environmental payments in Poland. At the regional level, this ranges from 11.7% in Kuyavia-Pomerania to over 50% in Lubusz and Subcarpathia (see Table 2). It is highly spatially diverse at the commune level, as seen in the significant differences in the number of communities in which habitat payments dominate (representing over 70% of payments) between the provinces of Kuyavia-Pomerania (6 communities), Łódź (8), Opole (2) and Lower Silesia (44), Lesser Poland (38), Masovia (51) and Subcarpathia (70; see Figure 6b).

One very important observation is that the determinants correlated negatively with environmental conditions ($r = -0.319$), which include, inter alia, the share of protected areas. The dependence was not confirmed by analysis according to groups of determinants (↑, ↓), because, in this case, the difference between thegroups of below-average and above-average communitieswas over 13% (Table 2).

3.4. Typology of Pro-Environmental Forms of CAP Support

The above-described types of support for green agriculture, with its three directions (organic—O, environmental—E, habitat—H), were subjected to structural analysis using the D'Hondt method. They were shown to form highly diverse breakdowns within the structure of examined communities, including as many as 28 combinations of characteristics or types of support. These characteristics and support types were highly differentiated in the numbers of communities that they related to—from 1.4% of all examined communities (33 communities—No. 22; Table 3) for O1 E1 H4 (very low level of support for organic and environmental farming, and a significant share of support for habitat farming) to 20.7% (472 communities—No. 9) for E6 (dominant share of support for environmental farming; Table 3).

In order to generalise these spatial structures showing the pro-environmental support for agriculture using the criterion of the dominant number of quotients, four main types of support were defined: organic farming (O), environmental agriculture (E), habitat farming (H) and equal share of directions (ES). Within these, seven subtypes were distinguished, splitting each type into two, i.e., a very high share or total dominance (5 or 6 quotients) and a very low, low, significant or high share (1, 2, 3 or 4 quotients) (Table 3).

Assuming types as the basic division in the spatial analysis, the average relation for Poland is O2 E2 H2 (equal and very low share of land covered by organic, environmental and habitat farming subsidies). At the regional level, the same type characterises Masovi-aProvince. Analysis by type showed the remaining provinces to be differentiated in terms of the leading direction of support, i.e.,

- organic farming—three provinces: Podlasie, Warmia-Masuria and West Pomerania (type E2—all with three quotients);
- environmental agriculture—eight provinces: two of type R1 (Kuyavia-Pomerania—six R quotients, Opole—five R quotients) and six of type R2 (three R quotients for Lublin, Łódź, Silesia, Holy Cross and Greater Poland; and four R quotients for Pomerania);
- habitat farming—four provinces: one of type S1 (Subcarpathia—five quotients) and three of type S2 (Lower Silesia, Lubusz, Lesser Poland—three quotients; see Table 3).

The regional variability of the distinguished types is confirmed by their spatial differentiation by commune, including in a type's share in the total number of examined communities within a province, i.e.,

- organic type (O): national average 21.3%, including the highest number in the provinces of Lesser Poland—33.3%, Podlasie—37.3% and, above all, in Warmia-Masuria—53.3%;
- environmental type (E): national average 41.5%, including the most in the provinces of Kuyavia-Pomerania—83.2%, Lublin—52.2%, Łódź—62.2%, Opole—81.6%, Pomerania—63.9% and Greater Poland—72.4%;
- habitat type (H): national average 27.7%, including the largest number in the provinces of Lower Silesia—45.6%, Lubusz—48.7%, Podlasie—37.3% and, above all, Subcarpathia—60.1%;
- equal share (ES): national average 8.8%, including the highest number in the provinces of Lubusz—17.9% and Warmia-Masuria—15.2% (see Figure 7).

The distinguished structural types were also analysed in terms of the adopted determinants. It has been shown that the national average—the RU type (O2 E2 H2)—characterises a group of communities with above-average (↑) agricultural determinants, while those that were below average (↓) were type R2. On the other hand, for environmental determinants, those communities with less favourable conditions were, on average, type R2, whereas above-average (↑) communities were found to be type S2 (see Table 2).

In general, the analysis showed a very strong spatial differentiation in the analysed green activities. This indicates that there are factors guiding farm owners in deciding whether to participate in CAP-financed environmental programmes. It has been shown that a combination of environmental awareness and the need to implement good practices that consider environmental wellbeing is insufficient. This therefore indicates the need for further research on the rationality and effectiveness of the implemented actions, both by us and by other researchers in the field. This is particularly important because this issue is very closely related to the new set of political initiatives being implemented across the EU, i.e., the EGD. An appropriate level of financial support and the reallocation of funds under pro-environmental measures can significantly support the achievement of EGD goals (e.g., increased biodiversity, healthy food, sustainable agriculture, climate neutrality).

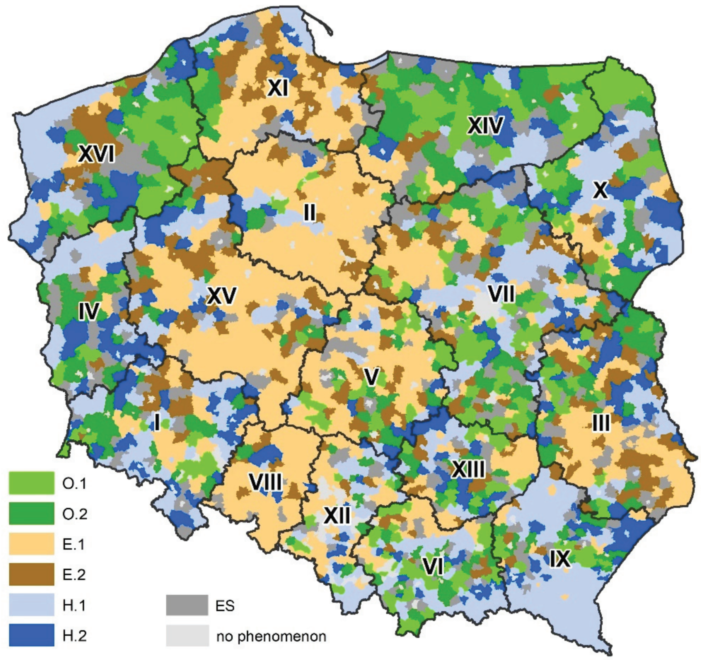


Figure 7. Structural types of farmland covered by pro-environmental CAP measures. Source: own elaboration.

4. Discussion

The low correlation (or lack thereof) between the directions of the analysed CAP payments and the natural characteristics adopted (as a determinant) indicates that the environmental factor has a low impact for a major criterion in decisions to develop green directions for agriculture. It is more common that the decisive factors in such matters are de facto situational factors related to access to and potential to use EU funds. In making decisions, farmers are mainly guided by the economic (income) criterion. There is thus a noticeable deficit in the criteria taken into account when territorially targeting these funds (i.e., ecology, environmental care, rational management, development of sustainable agriculture), which weakens the rationality of their spending [38]. Reversed correlation patterns are no exception and are also observed in other countries, such as Germany [39]. This may be due to both purely economic reasoning (lower income effects) and psychological factors related to differences in attitudes between farmers, including attitudes that limit their available choices of how to manage their farms [40–42].

The results indicate the spatial dualism of pro-environmental RPD support. Subsidies to develop sustainable agriculture and protect soils and waters (the environmental farming type) were particularly important in a cohesive belt of communities (in the provinces of Opole, Greater Poland, Kuyavia-Pomerania, Pomerania, Łódź and Masovia). These are areas where highly developed, intensive and often specialised agriculture predominates [43]. The share of subsidised land in these provinces is decidedly below the national average, and this—in combination with the specific nature of the measures taken (which are less demanding than organic and habitat farming)—confirm the research conclusion of Barreiro-Hurlé et al. [44] that a high agricultural income discourages farmers from participating in the AECMs. However, it should be noted that there are also opposite findings in the literature. According to studies carried out on the example of Belgian farmers, the larger the farm, the more the AECM; the less land, the more the AECM [45].In the other areas, support is more diverse, as confirmed by the more random scattering of types, while these areas also feature smaller territorial clusters of communities focused on developing ecological and habitat farming. The breakdown of agriculture in these areas is diverse [42]. There are both large farms based on former state farms (Northern and Western Poland) and small, less economically effective family farms on lower-quality land [46].

The analysis results confirm the conclusions of studies conducted by, among others, Bàrberi et al. [47] that there is a tendency towards spatial segregation between highly specialised, productive areas and areas with small-scale, low-input farming. In terms of the intensity of agricultural production, pro-environmental forms of support were found to have a low share in regions of intensive production (in Poland, see the provinces of Greater Poland, Kuyavia-Pomerania, Opole), which is consistent with the results of research by Frueh-Mueller et al. [48]. At the same time, they converge with results for other countries (incl. Germany, France, Spain, Hungary [26]).

Generally, it should be noted that, in the whole EU, the rank of pro-ecologically oriented activities is gradually increasing, which is derived from a change in priorities and the successive strengthening of this direction of development [49]. As a result, the allocation of public funds to the development of organic farming in the EU countries has gradually been increasing over the last three decades and becoming more available [50].Despite the change in the direction of the agricultural policy strengthening environmentally friendly forms of production, there is still a large gap between funds aimed at conventional agriculture and expenditure on agri-environmental measures (the funds accounted for around 7%, i.e., nearly EUR 20 billion, of total EU funding for the CAP 2014-20; European Commission, 2013). Even in the countries with the highest input rates for organic farming in the EU (Germany), this represents only a small part of the total expenditure on agricultural policy [50,51].In order to effectively manage and influence the rationality of spending funds from AECM and OFS activities, in line with the objectives of EU environmental policy, the funds should include a regional component—as is the case in Germany, where each state has specific autonomy in creating a development policy taking into account the existing conditions [52]. Regarding geographically targeted measures, it should be remembered that CAP funds can have a positive effect and prevent the abandonment of agricultural land in these areas, especially for seminatural habitats with low agricultural productivity [53] and negative habitats where intensive practices are more profitable, e.g., higher animal densities are limited [54].

In this respect, high hopes are attached to the new EU policy known as the European Green Deal (EGD), which aims to boost the role of environmental activities. The policy significantly enhances the role and prominence of organic farming. The key objective is to increase the output and consumption of organic products, inter alia, by having 25 percent of farmland used for organic farming by 2030 and substantially expanding organic aquaculture. Based on the findings of the study, it is assumed that work on the preparation of action plans dedicated to organic production should take into account the disparities between regions in terms of their natural potential for the development of modern, effective organic farming. Properly addressed support will enable the ambitious goals set by the European Commission and the assumptions resulting from the EGD to be achieved.

The obtained results and their high degree of spatial differentiation indicate the need for further research on farmlands covered by pro-environmental CAP subsidies. The EU's Farm to Fork Strategy and the Biodiversity Strategy set ambitious goals for the agricultural sector in order to ensure that it is prepared to adapt to the objectives of the European Green Deal. Pro-ecological forms of agricultural support (AECM, OF and others) will be a key element in the transition to a more sustainable food system and in better protecting biodiversity. With the use of appropriate policies and the right legal framework, the European Commission is tasked with supporting pro-ecological forms of farming in achieving the goals designated in the EGD. The future perspective of the CAP, which will include eco-programmes supporting the development of pro-ecological forms of agriculture, will help in the implementation of this task. Such studies, especially those using the proposed three-way division of forms of support, are of great descriptive (scientific) and applied value. This is indicated by, for example, the spatial distributions of pro-environmental activities in relation to the environmental conditions and agricultural characteristics. Areas predisposed to the greening of agriculture were shown to exist, however, with small areas covered by pro-environmental RDP subsidies. These areas should be treated as a reservoir for the future development of pro-environmental management in agriculture. The developed synthetic approach to pro-environmental CAP support combines information that is traditionally illustrated by a range of individual indicators. The advantage of this in terms of the applicability of results is its legibility and ease of interpretation (names clearly indicating the nature of the division), made possible by the use of the D'Hondt method.

5. Conclusions

The breakdown and variety of pro-environmental forms of support in RDP 2014-20 is very diverse, as seen in the number of identified structural types. The range of instruments supporting and promoting green forms of agricultural land use is thus relatively wide. The analysis showed that, from a structural point of view, the implementation of pro-environmental measures is highly comprehensive, accurately reflecting real-world needs, and should be assessed positively, because the range of available support must meet the various needs of agriculture that result from the diversity of both environmental conditions and farm characteristics (e.g., farm size). One problematic issue diagnosed during the study is the quantitative aspect, especially the low, currently unsatisfactory share of agricultural land receiving subsidies from the measures in question. Their share in Poland averaged 9.2% of agricultural land, while the share of lands subsidised by organic farming programmes (with the most demanding qualification requirements) was only 3%. This percentage, compared to the EGD's postulated 25% of organic farming in the EU's total agricultural area, clearly indicates a major problem and challenge for Polish agriculture on its road towards sustainable development. Poland currently stands towards the back of the pack in terms of the share of land devoted to the organic farming of crops (with only Romania, Bulgaria and Ireland in worse positions) [55]. These relations indicate insufficient efforts by the institutions responsible for implementing EU funds in Poland.

To achieve the EGD objectives, it will be necessary to intensify activities to promote pro-environmental activities co-financed by the CAP. The authors recommend that this task should first focus on increasing the area of farmland subsidised by pro-environmental CAP support, taking into account the three subsidy types for the three specific types of agriculture:

- ecological: the need to intensify activities aimed at growing this land category due to current trends in the development of farms being promoted by, among others, the EGD;
- environmental: the need to more heavily promote pro-environmental practices in agriculture, especially in environmentally valuable areas covered by various forms of protection (including legal protection);
- habitat: the need to regulate the status of farms that have valuable natural habitats of key importance in terms of protecting nature and biodiversity and that are not used for producing food using natural substances and processes (the main characteristic of organic farming).

Moreover, it is recommended to introduce changes to more rationally manage and target pro-environmental payments from AECM and OF activities, which would ultimately strengthen the synergistic effects resulting from the positive impact that non-conventional agriculture has on the preservation of natural ecosystems and biodiversity. The current state of affairs is reducing the effectiveness of support, which is not in line with CAP objectives. The changes should be based on, inter alia, a spatial criterion, i.e., one that takes into account the natural specificity of individual regions. Presently, synergistic effects are significantly limited and it is necessary to consider at least partially reorienting fund allocations in a more territorial direction. The training of farmers in environmentally friendly farming methods is also necessary.

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Appendix A

Table A1. Pro-environmental agricultural payments: forms of support and areas covered by subsidies.

Packages/Variants	RDP Green Measures in Agriculture: Total	Thousand ha 1284.9	% 100.0
	Agri-environmental–climate measure (AECM)	864.5	67.3
I	**Sustainable agriculture**	268.1	20.9
II	**Protection of soils and waters**	129.0	10.0
II.1	Catch crops	128.9	10.0
II.2	Protective strips on slopes steeper than 20%	0.0	0.0
III	**Preserving orchards of traditional fruit tree varieties**	0.6	0.0
IV	**Valuable bird habitats and endangered bird species in Natura 2000 areas**	258.7	20.1
IV.1	Variable-humidity tall meadows	5.3	0.4
IV.2	Alluvial Cnidiondubii meadows and salt meadows	4.1	0.3
IV.3	Grasslands	4.7	0.4
IV.4	Semi-natural humid meadows	33.0	2.6
IV.5	Semi-natural Arrhenatherion meadows	69.0	5.4
IV.6	Bogs	6.7	0.5
IV.6.1	Peatlands—mandatory requirements	0.8	0.1
IV.6.2	Peatlands—mandatory and supplementary requirements	5.9	0.5
IV.7	Extensive land use in special bird protection areas (SPAs)	27.0	2.1
IV.8	Protection of breeding habitats of black-tailed godwit, common snipe, redshank or lapwing	83.8	6.5
IV.9	Protection of breeding habitats of aquatic warbler	8.1	0.6
IV.10	Protection of breeding habitats of great snipe or common curlew	12.5	1.0
IV.11	Protection of breeding habitats of corncrake	4.5	0.4
V	**Valuable habitats outside Natura 2000 areas**	197.2	15.4
V.1	Variable-humidity tall meadows	6.0	0.5
V.2	Alluvial Cnidiondubii meadows	1.0	0.1
V.3	Grasslands	8.5	0.7
V.4	Semi-natural humid meadows	72.2	5.6
V.5	Semi-natural Arrhenatherion meadows	106.4	8.3
V.6	Bogs	3.1	0.2
V.6.1.	Peatlands—mandatory requirements	0.4	0.0
V.6.2.	Peatlands—mandatory and supplementary requirements	2.7	0.2

Table A1. *Cont.*

Packages/Variants	RDP Green Measures in Agriculture: Total	Thousand ha 1284.9	% 100.0
	Agri-environmental–climate measure (AECM)	864.5	67.3
VI	**Preservation of endangered plant genetic resources in agriculture**	11.0	0.9
VI.1	Preservation of endangered plant genetic resources in agriculture—crop farming	9.4	0.7
VI.2	Preservation of endangered plant genetic resources in agriculture—seed material or seed production	1.6	0.1
VII	**Organic farming (OF)**	420.4	32.7
VII.1	Payments during conversion period	95.2	7.4
VII.1.1	Crops during conversion period	49.5	3.9
VII.1.2	Vegetable crops during conversion period	6.5	0.5
VII.1.3	Herbaceous crops during conversion period	7.0	0.5
VII.1.4	Fruit crops during conversion period	5.8	0.5
VII.1.4.1	Basic fruit crops during conversion period	2.1	0.2
VII.1.4.2	Berry crops during conversion period	2.5	0.2
VII.1.4.3	Extensive fruit crops during conversion period	1.1	0.1
VII.1.5	Fodder crops during conversion period	18.2	1.4
VII.1.6	Permanent pasture during conversion period	8.3	0.6
VII.2	Post-conversion payments	325.1	25.3
VII.2.1	Post-conversion crops	151.9	11.8
VII.2.2	Post-conversion vegetable crops	17.1	1.3
VII.2.3	Post-conversion herb crops	16.4	1.3
VII.2.4	Post-conversion fruit crops	0.0	0.0
VII.1.4.1	Post-conversion basic fruit crops	2.5	0.2
VII.1.4.2	Berry crops during conversion period	9.9	0.8
VII.1.4.3	Post-conversion extensive fruit crops	3.1	0.2
VII.1.5	Post-conversion fodder crops	89.4	7.0
VII.1.6	Post-conversion permanent pasture	34.9	2.7

Source: own study based on data from ARMA and LDB.

References

1. Bateman, I.J.; Balmford, B. Public funding for public goods: A post-Brexitperspective on principles for agricultural policy. *Land Use Policy* **2018**, *79*, 293–300. [CrossRef]
2. Treasury, H.M. The Green Book: Central Government Guidance on Appraisal and Evaluation. London, UK. 2018. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf (accessed on 20 September 2021).
3. Ecorys. Mapping and Analysis of the Implementation of the CAP. 2017. Available online: https://op.europa.eu/pl/publication-detail/-/publication/65c49958-e138-11e6-ad7c-01aa75ed71a1 (accessed on 22 August 2021).
4. Wiśniewski, Ł.; Rudnicki, R.; Chodkowska-Miszczuk, J. What non-natural factors are behind the underuse of EU CAP funds in areas with valuable habitats? *Land Use Policy* **2021**, *108*, 105574. [CrossRef]
5. Marsden, T.; Sonnino, R. Rural development and the regionalstate: Denyingmultifunctionalagriculture in the UK. *J. RuralStud.* **2008**, *24*, 422–431. [CrossRef]
6. Hanley, N.; Banerjee, S.; Lennox, G.D.; Armsworth, P.R. How shouldweincentivizeprivatelandowners to 'produce' morebiodiversity? *Oxf. Rev. Econ. Policy* **2012**, *28*, 93–113. [CrossRef]
7. Home, R.; Balmer, O.; Jahrl, I.; Stolze, M.; Pfiffner, L. Motivations for implementation of ecologicalcompensationareas on Swiss lowlandfarms. *J. Rural Stud.* **2014**, *34*, 26–36. [CrossRef]
8. Kleijn, D.; Sutherland, W.J. How effectiveareEuropeanagri-environment schemes in conserving and promotingbiodiversity? *J. Appl. Ecol.* **2003**, *40*, 947–969. [CrossRef]
9. Pe'er, G.; Zinngrebe, Y.; Moreira, F.; Sirami, C.; Schindler, S.; Müller, R.; Hansjürgens, B. A greenerpath for the EU common agricultural policy. *Science* **2019**, *365*, 449–451. [CrossRef]
10. European Commission. *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, The European Green Deal, COM (2019) 640 Final*; European Commission: Brussels, Belgium, 2019.
11. Jaeger, C.; Mielke, J.; Schütze, F.; Teitge, J.; Wolf, S. The European Green Deal—More Than Climate Neutrality. *Intereconomics* **2021**, *56*, 99–107. [CrossRef]

12. European Commission. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Sustainable Europe Investment Plan. European Green Deal Investment Plan, COM(2020) 21 Final*; European Commission: Brussels, Belgium, 2020.
13. European Commission. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Farm to Fork Strategy for a Fair, Healthy and Environmentally-Friendly Food System, COM(2020) 381 Final*; European Commission: Brussels, Belgium, 2020.
14. Arabska, E. From Farm to Fork: Human Health and Well-Being through Sustainable Agri-Food Systems. *J. Life Econ.* **2021**, *8*, 11–27. [CrossRef]
15. Schebesta, H.; Candel, J.J.L. Game-changing potential of the EU's Farm to Fork Strategy. *Nat. Food* **2020**, *1*, 586–588. [CrossRef]
16. Swinnen, J. *The Political Economy of Agricultural and Food Policies*; Palgrave Macmillan US: New York, NY, USA, 2018; p. 254.
17. Swinnen, J.; Vandevelde, S. The Political Economy of Food Security and Sustainability. *Encycl. Food Secur. Sustain.* **2019**, *1*, 9–16. [CrossRef]
18. Rudnicki, R. *The Spatial Structure of Polish Agriculture Conditioned by Common Agricultural Policy Instruments*; Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika: Toruń, Poland, 2016; p. 208.
19. Pe'er, G.; Bonn, A.; Bruelheide, H.; Dieker, P.; Eisenhauer, N.; Feindt, P.H.; Hagedorn, G.; Hansjürgens, B.; Herzon, I.; Lomba, A.; et al. Action needed for the EU Common Agricultural Policy to address sustainability challenges. *PeopleNat.* **2020**, *2*, 305–316. [CrossRef]
20. Matin, S.; Sullivan, C.A.; ÓhUallacháin, D.; Meredith, D.; Moran, J.; Finn, J.A.; Green, S. Predicted distribution of High Nature Value farmland in the Republic of Ireland. *J. Maps* **2016**, *12*, 373–376. [CrossRef]
21. *Rozporządzenie Ministra Rolnictwa iRozwoju Wsi z Dnia 18 Marca 2015 r. w Sprawie Szczegółowych Warunków I Trybu Przyznawania Pomocy Finansowej w Ramach działAnia "Działanie Rolno-środowiskowo-klimatyczne" Objętego Programem Rozwoju Obszarów Wiejskich na Lata 2014–2020: Regulation of the Minister of Agriculture and Rural Development of 18 March 2015 on the Detailed Conditions and Procedure for Granting Financial aid under the Action "Agri-Environment-Climate" under the Rural Development Program for 2014–2020, 24 marca 2015 r. Poz. 415*; Ministerstwo Rolnictwa I Rozwoju Wsi: Warszawa, Polska, 2015. Available online: http://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20150000415/O/D20150415.pdf (accessed on 22 August 2021). (In Polish)
22. *Rozporządzenie Ministra Rolnictwa I Rozwoju Wsi z Dnia 27 Lutego 2019 r. Zmieniające Rozporządzenie w Sprawie Szczegółowych Warunków I Trybu Przyznawania Pomocy Finansowej w Ramach działAnia "Rolnictwo Ekologiczne" Objętego Programem Rozwoju Obszarów Wiejskich na Lata 2014–2020: Ordinance of the Minister of Agriculture and Rural Development of February 27, 2019 Amending the Ordinance on Detailed Conditions and Procedure for Granting Financial Aid under the Measure "Organic Farming" Covered by the Rural Development Program for 2014–2020*; Ministerstwo Rolnictwa I Rozwoju Wsi: Warszawa, Polska, 2015. Available online: http://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20190000451/O/D20190451.pdf (accessed on 22 August 2021). (In Polish)
23. Adamowicz, M. Bioeconomy-concept, application and perspectives. *Probl. Agric. Econ.* **2017**, *1*, 29–49. [CrossRef]
24. Jezierska-Thöle, A.; Biczkowski, M. Financial Funds from European Union funds as a chance for the development of the sector of organicfarms in Poland. *Assoc. Agric. Agribus. Econ.* **2017**, *19*, 95–101. [CrossRef]
25. Galler, C.; von Haaren, C.; Albert, C. Optimizing environmentalmeasures for landscapemultifunctionality: Effectiveness, efficiency and recommendations for agri-environmentalprograms. *J. Environ.Manag.* **2015**, *151*, 243–257. [CrossRef]
26. Farmer, M.; Cooper, T.; Swales, V.; Silcock, P. Funding for Farmland Biodiversity in the EU: Gaining Evidence for the EU Budget Review: A Report for the RSPB. 2008. Available online: https://ieep.eu/archive_uploads/628/IEEP_2008_Funding_for_Farmland_Biodiversity_in_the_EU_Final.pdf (accessed on 22 August 2021).
27. Racine, J.B.; Reymond, H. *Quantitative Analysis in Geography*; PWN: Warsaw, Poland, 1977; p. 255. (In Polish)
28. Czyż, T. Metoda wskaźnikowa w geografi ispołeczno-ekonomicznej: Method indicator in social and economic geography. *Rozw. Reg. iPolityka Reg.* **2016**, *34*, 9–19. (In Polish)
29. D'Hondta, W. *Système Pratique Et Raisonné De Représentation Proportionnelle*; Librairie, C. Muquardt: Bruksela, Belgium, 1882; Available online: https://www.e-rara.ch/bau_1/doi/10.3931/e-rara-39876 (accessed on 29 August 2021). (In French)
30. Rudnicki, R.; Dubownik, A.; Biczkowski, M. Diversification of sources of income in agricultural holdings in the context of multi-functional development of rural areas in Poland. *Belgeo* **2016**, *4*. Available online: https://journals.openedition.org/belgeo/19722?lang=de#quotation (accessed on 30 May 2021). [CrossRef]
31. Bakos, K.L.; Dobos, A.; Nagy, J. Mapping agricultural performance and environmental parameters aimed at generic regional studies. *Acta Agrar. Debr.* **2012**, *49*, 29–34. [CrossRef]
32. Medzihorsky, J. Rethinking the D'Hondt method. *Polit. Res. Exch.* **2019**, *1*, 1–15. [CrossRef]
33. Wysocki, F. *Metody Taksonomiczne w Rozpoznawaniu Typów Ekonomicznych Rolnictwa I Obszarów Wiejskich: Taxonomic Methods in Identifying Economic Types of Agriculture and Rural Areas*; Wydawnictwo Uniwersytetu Przyrodniczego: Poznań, Poland, 2010; p. 399. (In Polish)
34. Falkowski, J.; Kostrowicki, J. *Geografia Rolnictwa Świata*; PWN: Warsaw, Poland, 2001; p. 515. (In Polish)
35. Rudnicki, R.; Jezierska-Thöle, A.; Wiśniewski, Ł.; Jorg, J.; Kozłowski, L. Former political borders and their impact on the evolution of the present-day spatial structure of agriculture in Poland. *Stud. Agric. Econ.* **2018**, *120*, 8–16. [CrossRef]
36. Bański, J.; Mazur, M. (Eds.) *Atlas Rolnictwa Polski: Atlas of Polish Agriculture*; IGiPZ PAN: Warsaw, Poland, 2010; Available online: https://www.igipz.pan.pl/atlas-rolnictwa-polski-zgwirl.html (accessed on 29 August 2021). (In Polish)

37. Grajewski, R.; Schmidt, T.G. *Agrarumweltmaßnahmen in Deutschland: Förderung in den Ländlichen EntwicklungsprogrammenimJahr 2013*; Thünen Working Paper 44; Johann Heinrich von Thünen-Institut: Braunschweig, Germany, 2013. (In German)
38. Wiśniewski, Ł.; Biczkowski, M.; Rudnicki, R. Natural potential versus rationality of allocation of Common Agriculture Policy funds dedicated for supporting organic farming development—Assessment of spatial suitability: The case of Poland. *Ecol. Indic.* **2021**, *130*, 108039. [CrossRef]
39. Früh-Müller, A.; Bach, M.; Breuer, L.; Hotes, S.; Koellner, T.; Krippes, C.; Wolters, V. The use of agri-environmental measures to address environmental pressures in Germany: Spatial mismatches and options for improvement. *Land Use Policy* **2019**, *84*, 347–362. [CrossRef]
40. Schmit, C.; Rounsevell, M.D.A. Are agricultural land use patterns influenced by farmer imitation? *Agric. Ecosyst. Environ.* **2006**, *115*, 113–127. [CrossRef]
41. Brady, M.; Kellermann, K.; Sahrbacher, C.; Jelinek, L. Impacts of Decoupled Agricultural Support on Farm Structure, Biodiversity and Landscape Mosaic: Some EUResults. *J. Agric. Econ.* **2009**, *60*, 563–585. [CrossRef]
42. Hartig, F.; Drechsler, M. Stay by thy neighbor? Social organization determines the efficiency of biodiversity markets with spatial incentives. *Ecol. Complex* **2010**, *7*, 91–99. [CrossRef]
43. Wiśniewski, Ł.; Perdał, R.; Rudnicki, R. Proposed method for delimiting spatial structure on the example of agriculture types in Poland. *Bull.Geogr. Socio-Econ. Ser.* **2020**, *49*, 7–18. [CrossRef]
44. Barreiro-Hurlé, J.; Espinosa-Goded, M.; Dupraz, P. Does intensity of change matter? Factors affecting adoption of agri-environmental schemes in Spain. *J. Environ. Plan. Manag.* **2010**, *53*, 891–905. [CrossRef]
45. Vanslembrouck, I.; Van Huylenbroeck, G.; Verbeke, W. Determinants of the Willingness of Belgian Farmers to Participate in Agri-environmental Measures. *J. Agric. Econ.* **2002**, *53*, 489–511. [CrossRef]
46. Hynes, S.; Garvey, E. Modelling Farmers' Participation in an Agri-environmental Scheme using Panel Data: An Application to the Rural Environment Protection Scheme in Ireland. *J. Agric. Econ.* **2009**, *60*, 546–562. [CrossRef]
47. Bàrberi, P.; Burgio, G.; Dinelli, G.; Moonen, A.C.; Otto, S.; Vazzana, C.; Zanin, G. Functional biodiversity in the agricultural landscape: Relationships between weedsandarthropodfauna. *Weed Res.* **2010**, *50*, 388–401. [CrossRef]
48. Früh-Müller, A.; Krippes, C.; Hotes, S.; Breuer, L.; Koellner, T.; Wolters, V. Spatial correlation of agri-environmental measures with high levels of ecosystem services. *Ecol. Indic.* **2018**, *84*, 364–370. [CrossRef]
49. Jezierska-Thöle, A.; Rudnicki, R.; Wiśniewski, Ł.; Gwiaździńska-Goraj, M.; Biczkowski, M. The Agri-Environment-Climate Measure as an Element of the Bioeconomy in Poland—A Spatial Study. *Agriculture* **2021**, *11*, 110. [CrossRef]
50. Feindt, P.; Proestou, M.; Daedlow, K. Resilience and policy design in the emerging bioeconomy—The RPD framework and the changing role of energy crop systems in Germany. *J. Environ. Policy Plan.* **2020**, *22*, 636–652. [CrossRef]
51. Kirschke, D.; Hager, A.; Jechlitschka, K.; Wegener, S. Distortions in a multi-level co-financing system: The case of the agri-environmental programme of Saxony-Anhalt. *German J. Agric. Econ.* **2007**, *56*, 297–304.
52. Uthes, S.; Matzdorf, B. Studies on agri-environmental measures: A survey of the literature. *Environ. Manag.* **2013**, *51*, 251–266. [CrossRef]
53. Dupraz, P.; Rainelli, P. Institutional approachestosustain rural landscapesin France. In *Sustaining Agriculture and the Rural Environment; Governance, Policy and Multifunctionality*; Brouwer, F., Ed.; Edward Elgar Publishing: Northampton, UK, 2004; pp. 162–182. Available online: https://www.e-elgar.com/shop/gbp/sustaining-agriculture-and-the-rural-environment-9781843762560.html (accessed on 14 October 2021).
54. Desjeux, Y.; Dupraz, P.; Latruffe, L.; Maigne, E.; Cahuzac, E. Evaluating the impact of rural development measures on farm labouruse: A spatial approach. In Proceedings of the 2014 European Association of Agricultural Economists, Ljubljana, Slovenia, 26–29 August 2014; p. 11.
55. European Commission. *Organic Farming in the EU*; European Commission: Brussels, Belgium, 2021; Available online: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/factsheet-eu-organic-action-plan_en.pdf (accessed on 9 October 2021).

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Article

Spatiotemporal Patterns of Land-Use Changes in Lithuania

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Abstract: The spatially explicit assessment of land use and land-use change patterns can identify critical areas and provide insights to improve land management policies and associated decisions. This study mapped the land uses and land-use changes in Lithuanian municipalities since 1971. Additionally, an analysis was conducted of three shorter periods, corresponding to major national land-use policy epochs. Data on land uses, available from the Lithuanian National Forest Inventory (NFI) and collected on an annual basis with the primary objective of conducting greenhouse gas (GHG) accounting and reporting for the land use, land-use change, and forestry (LULUCF) sectors, were explored. The overall trend in Lithuania during the last five decades has been an increase in the area of forest and built-up land and decrease in the area of producing land, meadow/pasture, wetlands, and other land uses. Nevertheless, the development trends for the proportions of producing land and meadow/pasture changed trajectories several times, and the breakpoints were linked with important dates in Lithuanian history and associated with the reorganization of land management and land-use relations. Global Moran's *I* statistic and Anselin Local Moran's *I* were used to check for global and local patterns in the distribution of land use in Lithuanian municipalities. The proportions of producing land and pasture/meadow remained spatially autocorrelated during the whole period analysed. Local spatial clusters and outliers were identified for all land-use types used in GHG inventories in the LULUCF sector at all the time points analysed. Ordinary least squares (OLS) regression was used to explain the land-use change trends during several historical periods due to differing land management policies, utilizing data from freely available databases as the regressors. The percentage of variance explained by the models ranged from 37 to 65, depending on the land-use type and the period in question.

Keywords: land use; land-use change; forests; producing land; grassland; spatial autocorrelation; regression

1. Introduction

The monitoring of land-use changes is a key way to understand and assess the dynamic processes in landscapes under different time and spatial scales. A fast-growing human population, the exhaustive use of resources, and increasing environmental concerns have made land-use change monitoring an important topic on the international research agenda [1,2]. The interaction between human activity and land-use changes is an increasing focus of researchers [3,4] due to their impacts on the climate [5], ecosystems [6], water resources [7], soil quality [8], and socioeconomic systems [9]. Land-use changes due to biophysical factors and human activities are accelerating in different regions of the world [10–12]. Even though the issues related to land-use changes are global and cause severe problems in many countries, the change patterns are dependent on local conditions due to numerous factors, such as policies, management, economics, culture, human behaviour, and the environment [13–17]. Thus, it is extremely important to understand the processes shaping land-use changes at different scales, ranging from regional to global. Such knowledge is of critical importance to build the policies and management plans needed to understand and improve the land-use change trends [12,17–20].

Land-use change in Lithuania has always been dynamic. The radical political, economic, and social developments that took place in the country over the last half century undoubtedly had impacts on the land use. Official statistics indicate [21] that 45.6% of the country's area is covered by arable land, 33.5% by forest, 6.21% by meadows and natural pastures, 5.2% by wetland, 5.4% by built-up land, and 4.09% by other. The area proportions of all land-use types, except for agricultural land, have changed relatively steadily during the last five decades; however, the trends of producing land and grassland development changed their trajectories around 1990 and again in about 2005 [22]. The demand for up-to-date information on land cover and land-use changes is increasing due to rapid landscape development as a result of fast processes in the agricultural sector, the growth of urban areas, and the depopulation of some regions, followed by renaturalization [23]. To implement the European Landscape Convention (2020) [24], the Lithuanian authorities (the Environmental Protection Agency of the Ministry of Environment) conduct regular monitoring of landscape changes. Such monitoring delivers facts on landscape development peculiarities and the factors behind the trends, which are needed to predict potential future opportunities and risks [25]. Nevertheless, the data collected and methods of analyses differ from region to region. Scientific research in this area, to the best of our knowledge, has always been sparse. The changes of land cover structure were assessed on 100 test sites (totalling 2.5 km^2) in 1976–1986, 2005–2006, and 2012–2013 by the Institute of Geology and Geography (2008; 2015). Often, CORINE information was mobilized to assess the historical development of land cover [26–29]. Information related to land use in Lithuania may also be available from several nationwide GIS databases, such as the Spatial dataset of georeference base cadastre (GRPK) or the Land Parcel Identification System (KZS) Database, which are maintained by state institutions and available for free from the Spatial Information Portal of Lithuania (geoportal.lt). Together with the information on declared land uses and agricultural parcels, this could make an excellent land-use dataset for scientific research; however, such data are only available from 2010 onward. Usually, only the most recent version of the data is freely available. Thus, the availability of suitable data could be another reason behind the limited research focus on land-use retrospection.

Land use and its changes are not only important for the development of the economy or the protection of the environment but are also recognized as having a significant impact on human-induced greenhouse gas (GHG) emissions [30,31]. Land use and its changes may result in GHG removal if certain active measures are applied, such as afforestation, reforestation, revegetation, etc. [32,33]. In order to estimate such emissions and removals, the land use, land-use change, and forestry (LULUCF) sector's GHG reporting was included under the requirements of UNFCCC reporting. Despite the sector's ability to capture GHG emissions from the atmosphere and sequestrate it in biomass or soil, the LULUCF sector was not included in the climate change mitigation target until 2021 [34]. Beginning in 2021, the LULUCF sector will play a role in the flexibility option to reach compliance with other sectors' GHG emission reduction target.

To meet its international climate change mitigation commitments and fulfil the obligation of reporting on GHG emissions and removals in the LULUCF sector, Lithuania introduced an original land-use monitoring system, which became an integral part of the National Forest Inventory (NFI), implemented by the State Forest Service [35,36]. The inventory uses a network of 16,349 systematically allocated sampling points. The land-use type and subtype were identified at each point following the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003), also taking into consideration the requirements of the United Nations Framework Convention on Climate Change and the Kyoto protocol for each year starting in 1971. Past land uses at each point were identified using available historical maps, such as topographic maps, land management maps, orthophotos, or satellite images [37]. The information collected in the sampling plots was used to prepare a land use and land-use change database, in addition to conventional forestry statistics, traditionally attributed to forest inventories. This information has been used in Lithuania to conduct greenhouse gas (GHG) accounting and reporting in the Land Use, Land-Use Change, and Forestry (LULUCF) sector since 2010. Usually, conventional land-use-data-based exercises are based on aggregated statistical information at the country level. Considerable spatial patterns of land-use distribution may be seen in a relatively small country such as Lithuania.

The fast progress of geographic information systems (GIS) during the last few decades provided researchers with powerful tools with which to conduct spatial analyses and modelling [38]. In Lithuania, there were few attempts to use GIS as a tool in land-use-related studies. For example, Kucas et al. [39] applied a multiscale analysis of forest fragmentation in Lithuania to demonstrate the technique with CORINE data. Lazdinis et al. [40] suggested an alternative—the average shortest distance to the closest forest—to forest cover percentage, better describing the spatial distribution of forested habitats for birds in an afforestation study. Jukneliene and Mozgeris [41] compared two GIS databases, representing the forest cover at a nominal scale of 1:10,000 and referring to two dates—1950 and 2013. The data were aggregated for the analyses up to the municipality level. The Global Moran's *I* statistic and Anselin Local Moran's *I* were used to identify global and local patterns in the distribution of forest cover characteristics in Lithuanian municipalities. The authors provided the reader with updated statistics on forest cover in Lithuania just after WWII and discussed the trends of forest cover dynamics during the second half of the 20th century. Recently, Manton et al. [42] used a local hotspot analysis to study peatlands in the Nemunas River basin. However, all these studies used wall-to-wall land-cover and land-use maps, referring to specific dates. The lack of continuously supplied information over time introduces some uncertainties in land-use change trajectories and, simultaneously, makes generalizing about land-use changes more challenging. A distinctive feature of the current study is that we analyse land-use data collected through sampling annually and covering the period since 1971. Another advantage of GIS is the opportunity to integrate for joint analysis data collected using different techniques, formats, time periods, and sometimes applications, but all sharing the same geographic location [22]. The availability of free multisource and multipurpose GIS data in the country has notably increased during the last decade since the implementation of the Spatial Information Portal of Lithuania [43]. All this potentially offers enhanced opportunities for a better understanding of the processes behind land-use development and facilitating land management policies.

The aim of current study is to map and explain the land-use changes in Lithuanian municipalities in the period since 1971. We map land use types that are considered the most significant in terms of carbon storage using land-use data originating from the Lithuanian NFI. Then, we evaluate and explain the land-use changes during different periods using factors that are extracted from freely available GIS databases. Finally, we discuss the spatial patterns observed in both land use and land-use change geography, associating them with land-use policy implications.

2. Materials and Methods

2.1. Study Area

The study focuses on land use and land-use changes in Lithuania. Geographically, even though Lithuania is situated in central Europe with central coordinates of 55°10′ N, 23°39′ E (Figure 1), it has strong historical links with Eastern Europe. The total land area of Lithuania is 65,200 km^2. Lithuania lies on the Eastern European Plain, with characteristic lowlands and hills (the highest point in the country is only 293 m above sea level). The terrain features numerous lakes and wetlands, and a mixed forest zone covers over 33% of the country. Lithuanian climate conditions and natural soil productivity are generally favourable for crop production. Consequently, more than 50% of its land area is used for agricultural purposes. Currently, Lithuania is dominated by rural landscapes, covering approximately 75% of its territory. The proportion of natural landscapes does not exceed

15% of the country's area and they are concentrated in the eastern and southeastern regions, the hilly western parts of the country, and the ancient delta on the shoreline [44]. The rest of the country is covered by rapidly expanding urban or urbanized landscapes. The administrative units of the Republic of Lithuania are 10 counties and 60 municipalities.

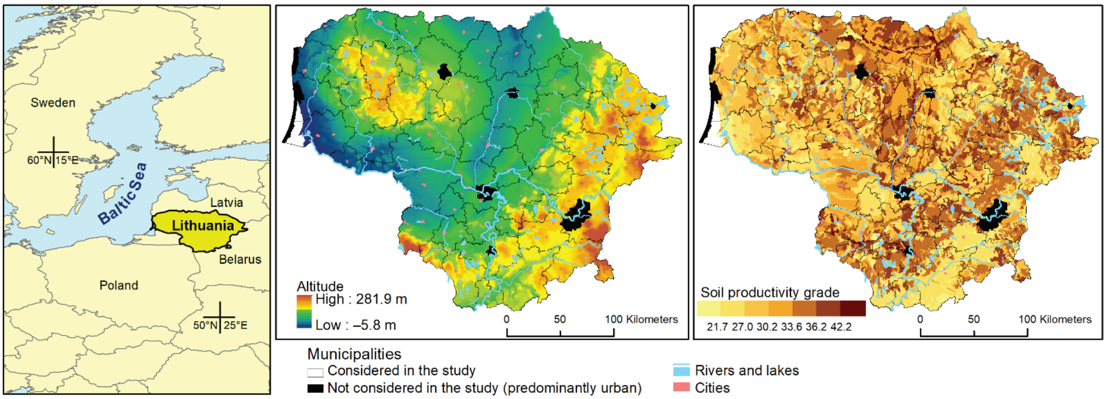

Figure 1. Specification of the study area: **left**—location of the study area in Europe, **centre**—elevation in Lithuania, **right**—average soil productivity grade. Sources of the data used: **left**—thematicmapping.org/downloads/world_borders.php (accessed on 13 May 2021), **centre**—GDB200 database from www.gis-centras.lt/ (accessed on 13 May 2021), **right**—derived using Dirv_DR10LT from www.geoportal.lt (accessed on 13 May 2021).

2.2. Input Data

Two types of input data were used in the study—(i) data describing the land uses in Lithuania and (ii) data describing the factors influencing the land-use changes. Land-use information was available from the Lithuanian National Forest Inventory, which involves permanent observation of land-use types on a network of 16,349 systematically distributed sampling plots [36,45]. NFI sampling plots are distributed in all land-use types across the country in clusters of four sampling plots on a 4 × 4 km grid. One-fifth of the sampling plots are visited each year by field measurement specialists; therefore, the whole country is covered in a five-year inventory cycle. Land-use types and subtypes are identified annually at the centre of each plot from 1971 using the nomenclature of GHG inventories [46], and land-use changes, if occurring, are detected and reported according to the measurement year. The land cover is further grouped according to the GHGC Level 1 coding of land cover: forest, producing land, grassland/pasture, wetlands, built-up areas, and other land. It should be noted that the identification and monitoring of land-use types became the responsibility of the Lithuanian NFI in 2011. To reconstruct the land-use types for each of the nonforest sampling plots for the period 1990–2011, a special study was conducted based on the use of all available historical materials, e.g., remotely sensed data, including orthophotos and satellite image archives, and land management and real estate maps [37].

Land-use statistics were aggregated to the level of Lithuanian municipalities. The borders of municipalities (USE_3 level) were acquired from EuroBoundaryMap (v3.0), which is a European reference database of administrative units and boundaries established within the framework of EuroGeographics (Available online: eurogeographics.org/maps-for-europe/ebm/, accessed on 13 May 2021). We excluded from the study nine predominantly urban municipalities (Figure 1); thus, the study was done on 51 municipalities with a mean area of 1260 km^2 (standard deviation = 452). The municipality for each observation point was identified using the Spatial Join tool of ArcGIS (v10.7) by specialists of the State Forest Service responsible for GHG inventories in the LULUCF sector. Summarized data on all the land-use types and subtypes from 1971 to 2015 were joined to the borders of each municipality. Usually, the proportions of observation points belonging to particular land-use types were calculated for each municipality and used in further analyses.

Free data available from the Spatial information portal of Lithuania (Available online: geoportal.lt, accessed on 13 May 2021) were used to describe the factors influencing the land-use changes. The datasets used to get the explanatory variables were the Georeference spatial dataset (GDR10LT), a soil spatial dataset at a scale of 1:10,000 (Dirv_DR10LT), a land reclamation and wetness dataset at a scale of 1:10,000 (Mel_DR10LT), a dataset of special land-use conditions at a scale of 1:10,000 (SŽNS_DR10LT), a dataset of abandoned agricultural land (AŽ_DRLT), CORINE land covers for 1995, 2000, 2006 and 2014, a land parcel block database referring to 2004, 2008 and 2014 (KŽS), population census data for 1970, 1989, and 2011, including geospatial data for 2011, data on agricultural crops declared to the National Paying Agency for 2010–2015, and a digital raster elevation model (cell size: 100 m) built based on information available in the GDB200 GIS database. Each vector dataset was overlain with the municipality polygons and summary statistics, such as total area or length, and the area/count proportion was extracted for a specific geographic object or phenomenon. If the explanatory variable was available in the raster, we used ArcGIS function Zonal Statistics to estimate the statistics of a certain attribute within each municipality. In the case, the geographical data required additional processing, so the standard functionality of ArcGIS Desktop was used. In such a way, e.g., the slope was estimated using the digital elevation model as the input. To estimate the population within a 15-min driving distance of the centre of each municipality, we used a road database, referring to the year 2007. The road network was constructed using input vector data corresponding to current data of the Georeference background cadastre (GRPK), with all field and forest roads included. Accessibility was calculated using standard ArcGIS Network Analyst New Service Area functionality within the framework of the FP7 RURALJOBS project [47]. Additionally, we used agricultural census data, available from the Official Statistics Portal of Lithuania [48]. All the attributes characterising the municipalities are summarised in Table A1.

2.3. Mapping and Evaluating the Land-Use Spatial Pattern

The proportions of forest, producing land, meadow/pasture, wetlands, built-up land, and other land in municipalities were plotted on the map. The Global Moran's I statistic and Anselin Local Moran's I were used to identify global and local patterns in the distribution of land-use characteristics in Lithuanian municipalities, respectively. To estimate the spatial distribution patterns, we used the spatial statistics tools available in ArcGIS Desktop. The land uses in municipalities were visualized and analysed at the following points: 1971, 1990, 2005, and 2015. The first and last years refer to the starting and ending points of land-use data available for the study, and the years 1990 and 2005 were chosen to correspond to the restoration of Lithuanian independence and joining the European Union, respectively. These dates also fit the overall development trajectories of producing land and meadow/pasture for the whole country [22]. To quantify the presence of a monotonic increasing or decreasing trend in the changes of land-use proportions during a specific period, we performed a nonparametric Mann–Kendall test and then estimated the slope of the linear trend with the nonparametric Sen's method using MAKESENS tools [49]. The spatial distribution of the slope was visualized and analysed using the same approaches as used with the land-use proportions and described above. The trends were analysed for the following periods: 1971–2015, 1971–1990, 1990–2005, and 2005–2015.

To understand the factors behind the land-use changes in Lithuanian municipalities, we applied an ordinary least squares (OLS) regression. The focus was on the changes in proportions of forest, producing land, and meadow/pasture during all the periods mentioned above. As the dependent variable, the slope of the linear trend in land-use proportion changes was used. All the variables extracted from the freely available GIS databases were considered as candidates for explanatory or independent variables. We checked all possible combinations of input candidate explanatory variables using the Exploratory Regression tool of ArcGIS Desktop. The number of independent variables ranged from two to five. The following conditions for the fit of the regression models were set: only explanatory variables with statistically significant coefficients (95% confidence level) and with a variance inflation factor under 7.5 were exploited to avoid multicollinearity; the minimum Jarque–Bera *p*-value was 0.1 to consider the model residuals to be normally distributed; and model residuals were tested for spatial clustering using Global Moran's *I* (maximum value allowed: 0.1) for the cases that met all the above search criteria. We evaluated the extent to which each candidate independent variable met the above conditions. Only the best regression models (in terms of adjusted R^2 and corrected Akaike information criterion, under the condition that all other statistical tests—Jarque–Bera statistic, Koenker (BP) statistic, variance inflation factor, and spatial autocorrelation of the regression residuals—were passed) are presented in the current paper.

The methodological framework of our study is summarized in Figure 2.

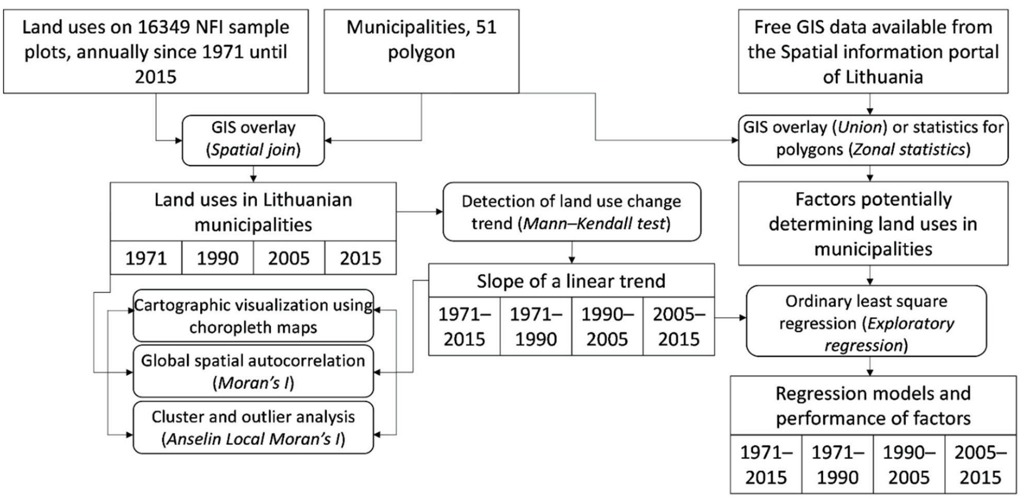

Figure 2. Flowchart summarizing the overall structure of the study.

3. Results

Agricultural landscapes dominate in Lithuania. Land-use types contributing the most to the carbon accumulation in the LULUCF sector (forest, producing land, and meadow/pasture) covered, in 1971, rather similar proportions of the country's area—each around 28–30%. The areas of other land uses accounted for less than 12%. Even though Lithuania is a small country, the land-use proportions in different parts of the country differed. Additionally, if taking into consideration only two years, i.e., 1971 and 2015, one could state that the areas of forest, producing land, and built-up land did increase, while the proportion of meadow/pasture, wetlands, and other land decreased. However, the trajectories of specific land-use development during shorter periods experienced notable changes.

Even though there is no statistically significant global autocorrelation in values of forest proportion in Lithuanian municipalities, the southeastern and western parts of the country are more forested (Figure 3). Lower forest proportions are found in northern and central municipalities, where producing land dominates. The global spatial autocorrelation of agricultural land proportions in Lithuanian municipalities—both producing land and pasture/meadow—was statistically significant at practically all the time points used for the analysis. Producing land dominated in the northern and central municipalities, with lower forest proportions. Larger proportions of pasture/meadow were reported in municipalities with higher forest proportions, but not along the southeastern border of the country with overall forest dominance. The proportions of other land uses in Lithuanian municipalities are notably lower and usually do not exhibit global spatial autocorrelation. The Anselin Local Moran's *I* statistic was used to explore the spatial clusters of features with high or low values, as well as the spatial outliers. Two clusters of municipalities with low proportions of forest area that were stable over time and neighboured by municipalities with low values were identified. They practically overlapped with the high–high clusters of producing land abundance. It should be noted that the high–high cluster of producing land proportion in the northern part of Lithuania was the highest one among all clusters identified in this study, made up of 4–7 municipalities. This cluster also overlapped with the low–low cluster of pasture/meadow. Municipalities in the eastern part of Lithuania made up the low–low cluster of producing land proportions, which partly overlapped with a high–high cluster of wetlands that was stable over time. A high–high cluster of meadow/pasture was identified in the western part of the country, in the lowland associated with the Nemunas Delta area. Spatial outliers were usually small, i.e., including just one municipality and associated with municipalities with forest proportions that were different from their neighbourhoods. Local clusters of proportions of built-up areas were also small and dispersed throughout the whole country. Local spatial clusters and outliers of other land exhibited rather random occurrence patterns over time; however, the low proportions of that land-use type in the municipalities should be kept in mind.

The areas of forest and built-up land increased in Lithuania since 1971, while the areas of producing land, pasture/meadow, wetlands, and other land went down—this is suggested by, respectively, the positive and negative values of the slope of the linear trend (Table 1). Stable development trajectories were followed by the proportions of forest, wetland, built-up land, and other land during the whole period under assessment; however, the areas of producing land and pasture/meadow did both increase or decrease during specific periods. Thus, the areas of producing land were increasing at the cost of a decrease in pasture/meadow from 1971 to 1990. By the end of this period, the area of producing land was at its highest level—36%. The area of producing land decreased since 1990, with the proportion of pasture/meadow increasing to be level with the areas of key agricultural land-use types in 2005, at a level of 28%. Finally, the trajectories as they were since 1971 were repeated after 2005.

Table 1. Trends of change in proportion of land-use types across the whole of Lithuania (significance level of slope: ***, 0.001; **, 0.01; and *, 0.05).

Land-Use Type	Trend Statistics for the Period under Review							
	1971–2015		1971–1990		1990–2005		2005–2015	
	Slope	Z Statistic	Slope	Z Statistic	Slope	Z Statistic	Slope	Z Statistic
Forest	0.085	9.67 ***	0.076	6.13 ***	0.064	5.36 ***	0.106	4.20 ***
Producing land	−0.027	−0.69	0.539	5.09 ***	−0.624	−5.36 ***	0.418	4.05 ***
Grassland/pasture	−0.031	−0.78	−0.579	−5.16 ***	0.612	5.36 ***	−0.542	−4.05 ***
Wetlands	−0.020	−9.52 ***	−0.023	−6.10 ***	−0.012	−4.95 ***	−0.007	−3.74 ***
Built-up land	0.009	6.79 ***	−0.001	−2.98 **	0.014	4.95 ***	0.015	3.97 ***
Other land	−0.015	−7.47 ***	−0.002	−2.37 *	−0.016	−4.86 ***	0.001	0.93

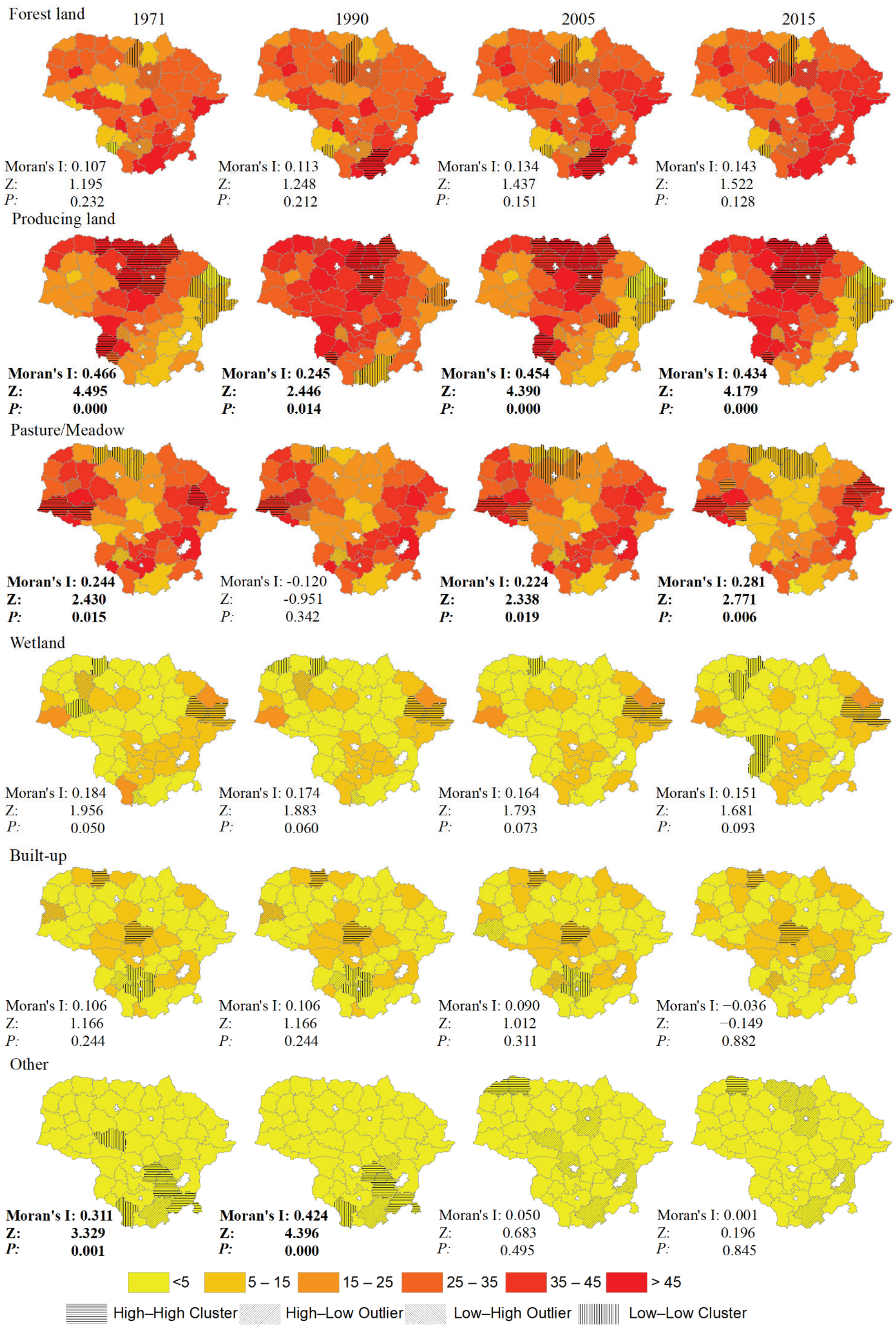

Figure 3. Area proportions of land-use types in Lithuanian municipalities during different periods since 1971. Statistically significant values of Global Moran's *I* statistic are in bold. Linear shades identify statistically significant hotspots, cold spots, and spatial outliers based on the Anselin Local Moran's *I* statistic.

Furthermore, the spatial patterns of changes in three land-use types in Lithuanian municipalities were analysed, i.e., forest, producing land, and pasture/meadow, and are presented in Figure 4. The slope of the linear trend of forest proportion changed both during the whole period (1971–2015) and in all three shorter spans in an interval between –0.5 and 0.5, suggesting rather slow development. Statistically significant global spatial autocorrelation in the slope values was observed only for 1971–1990. Even though the slope values were low, there were some spatial clusters and outliers identified, such as the low–low cluster suggesting aggregation of municipalities with decreasing forest proportion during 1971–2015 in the central part of the country and some southwestern municipalities since 1990 or the high–high cluster in 1971–1990 in municipalities along the border of the former Soviet Union and Poland. The slope of a linear trend for the development of forest proportion in 1971–2015 was statistically significant in practically all the municipalities. However, if shorter periods were taken into consideration, usually only positive slope values were statistically significant at the level of the municipality. The trends of producing land changes in the municipalities were inverse to the ones of pasture/meadow. This refers both to the value of the slope of linear trend and the types and the location of spatial clusters. The areas of producing land increased most intensively in 1971–1990 in the eastern and western parts of the country, resulting in statistically significant global spatial autocorrelation and local spatial clusters. However, since the restoration of independence in Lithuania in 1990, the proportion of producing land started to decrease, with the most intensive drop in the municipalities, where the increase was faster before 1990. Opposite trends could be reported for the development of pasture/meadow. Finally, since 2005, agricultural land uses changed their trajectories once again. Even though there is no statistically significant global autocorrelation in the value of the slope for the proportion of producing land—the area of this land-use type was increasing practically all municipalities, with some small spatial clustering effects—the decrease in pasture/meadow was faster in the central part of Lithuania (with the highest global Moran's I statistic among all the cases estimated). If the whole period of 1971 to 2015 is taken into consideration, the value of the linear slope for producing land and pasture/meadow was usually statistically nonsignificant for most of the municipalities, suggesting large fluctuations in land-use type proportions over the time. However, if taking into consideration shorter periods, the slope of linear trend was statistically significant in the majority of municipalities—e.g., for 1971–1990, there were just six municipalities with nonsignificant slope values for both producing land and pasture/meadow, or 10 and eight municipalities, respectively, for the period 1990–2005.

To explain the land-use change trends in Lithuanian municipalities during different periods of the last half-century, we used information available from different GIS databases and multiple linear regression. If taking into consideration the whole period (1971–2015), the best explained variable was the slope of steadily increasing forest proportion (Table 2). The best regression models explained 65% of the variance of the slope of forest proportion changes. The figures for producing land and pasture/meadow were, respectively, 40% and 37%. When considering a shorter period, the percentage of variance explained by forest change models decreased but increased in models for meadow and pasture. In the case of producing land, the coefficient of determination only increased in 1971–1990.

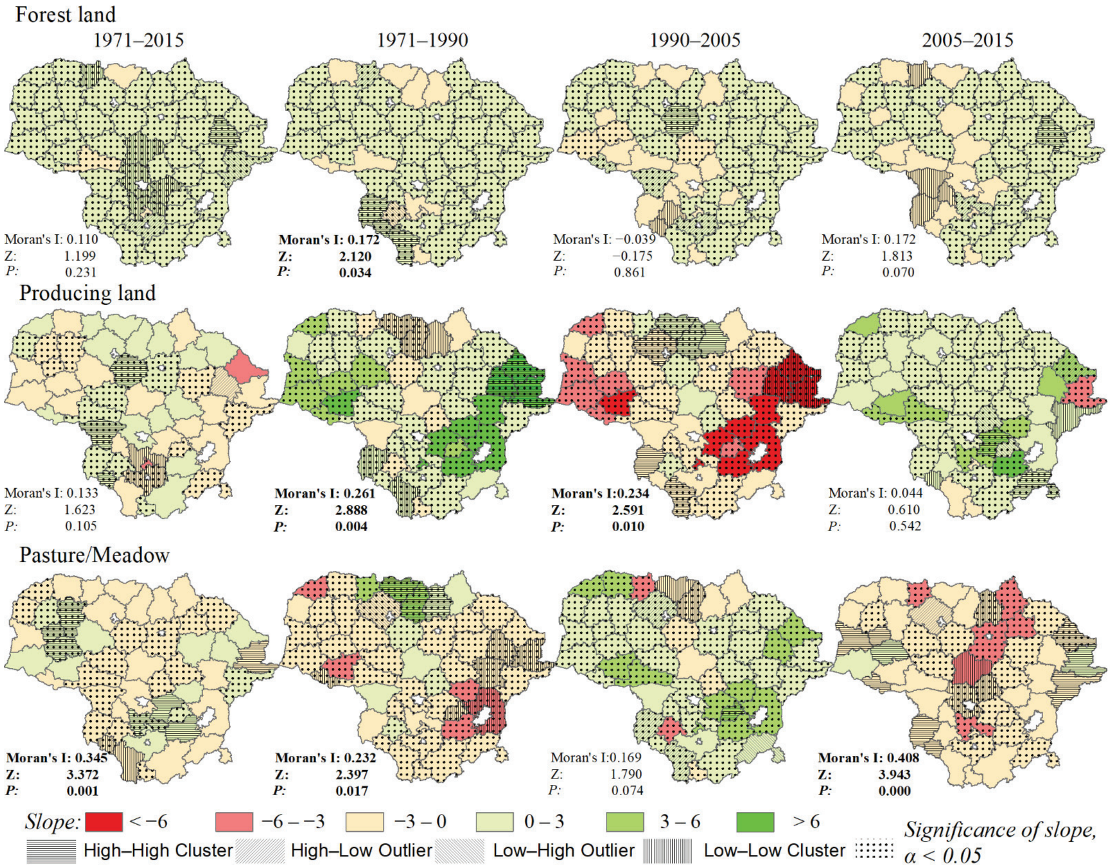

Figure 4. Slope of linear trend in changes of area proportions of main land-use types in Lithuanian municipalities during different periods since 1971. Statistically significant values of Global Moran's *I* statistic are in bold. Linear shades identify statistically significant hotspots, cold spots, and spatial outliers based on the Anselin Local Moran's *I* statistic. Dotted areas identify the statistical significance of the slope in a certain municipality.

The proportion of the time that each candidate explanatory variable was detected to be statistically significant, testing all potential combinations of variables, is illustrated in Figure 5. Usually, there were more variables with larger significance when modelling the change trends of forest. The abundance of land-use types in the beginning of each analysed period was among the most significant factors in most of the tested cases. Forest proportion in the municipality also had an impact on the development trends of other land uses. Soil productivity was another factor often present in the models. Terrain-related attributes played a more important role in forest and grassland change models. Topographic details participated in forest change models. It should be noted that the impacts of explanatory variables were similar in the forest and grassland change models but opposite when modelling the producing land development.

Table 2. Characteristics of best multiple linear regression models for each analysed dependent variable over different time periods.

Adjusted R^2	Corrected Akaike Information Criterion	Jarque–Bera Statistic	Koenker (BP) Statistic	Variance Inflation Factor	Moran's *I* of the Regression Residuals	Model
Period: 1971–2015						
Dependent Variable: Slope of Linear Trend of Forest Proportion Changes in Lithuanian Municipalities						
0.65	−64.94	0.68	0.21	1.60	0.39	1.474085 − 0.004053 × [Population density, 2011] ** − 0.02052 × [Soil productivity grade] *** + 0.003441 × [Standard deviation of altitude] − 0.010011 × [Forest, 1971] ***
Dependent Variable: Slope of Linear Trend of Producing Land Proportion Changes in Lithuanian Municipalities						
0.40	111.9	0.00	0.00	5.02	0.20−	0.39185 + 0.032059 × [Standard deviation of altitude] * − 5.077213 × [Mean slope] ** + 3.110821 × [Standard deviation of slope] ** − 0.395311 × [Grassland area per cattle-unit, 2014] *
Dependent variable: slope of linear trend of grassland proportion changes in Lithuanian municipalities						
0.37	43.33	0.12	0.55	4.89	0.40	−0.722898 + 1.852514 × [Mean slope] *** − 1.465708 × [Standard deviation of slope] ** + 0.012207 × [Grassland, 1971] *** + 0.000001 × [Protected areas] **
Period: 1971–1990						
Dependent Variable: Slope of Linear Trend of Forest Proportion Changes in Lithuanian Municipalities						
0.40	24.99	0.00	0.11	3.25	0.22	0.484 − 0.0049 × [Land reclamation intensity] + 0.003281 × [Minimum altitude] + 0.012543 × [Standard deviation of altitude] ** − 0.013414 × [Forest, 1971] ***
Dependent Variable: Slope of Linear Trend of Producing Land Proportion Changes in Lithuanian Municipalities						
0.45	322.44	0.00	0.04	5.83	0.82	−3.213562 + 0.826977 × [Soil productivity grade] ** − 0.1465 × [Land reclamation intensity] ** − 0.232591 × [Forest, 1971] *** − 0.433926 × [Producing land, 1971] ***
Dependent Variable: Slope of Linear Trend of Grassland Proportion Changes in Lithuanian Municipalities						
0.58	175.65	0.00	0.43	2.24	0.68	4.890114 − 0.009301 × [Range of altitude] * + 2.125683 × [Mean slope] − 0.070913 × [Forest, 1971] *** − 0.113908 × [Grassland, 1971] ***
Period: 1990–2005						

Table 2. *Cont.*

Adjusted R^2	Corrected Akaike Information Criterion	Jarque–Bera Statistic	Koenker (BP) Statistic	Variance Inflation Factor	Moran's *I* of the Regression Residuals	Model
Dependent Variable: Slope of Linear Trend of Forest Proportion Changes in Lithuanian Municipalities						
0.42	−41.24	0.36	0.08	2.34	0.45	1.686125 − 0.032764 × [Soil productivity grade] *** − 0.007497 × [Standard deviation of altitude] *** − 0.006543 × [Forest, 1990] *** + 0.000001 × [Area of agricultural blocks, 2004] *** − 0.000001 × [Area of water bodies, 2004] **
Dependent Variable: Slope of Linear Trend of Producing Land Proportion Changes in Lithuanian Municipalities						
0.34	349.86	0.00	0.01	2.62	0.80	−8.849178 + 0.277094 × [Land reclamation intensity] *** − 0.190026 × [Producing land, 1990] * − 0.000001 × [Protection zones of electricity lines] + 0.000001 × [Protected areas] ** − 0.000001 × [Area of water bodies, 2004] *
Dependent Variable: Slope of Linear Trend of Grassland Proportion Changes in Lithuanian Municipalities						
0.45	198.44	0.44	0.55	2.34	0.68	3.864368 − 0.072516 × [Land reclamation intensity] *** − 0.047102 × [Minimum altitude] *** + 0.018176 × [Range of altitude] *** − 0.000034 × [Population < 15-min drive to cities] ** + 0.000001 × [Area of water bodies, 2004] ***
Period: 2005–2015						
Dependent Variable: Slope of Linear Trend of Forest Proportion Changes in Lithuanian Municipalities						
0.47	12.58	0.33	0.08	2.04	0.88	−0.427383 + 0.003047 × [Mean slope] *** − 0.014434 × [Standard deviation of altitude] *** + 0.017336 × [Grassland, 2005] *** + 0.000001 × [Area of agricultural blocks, 2008] *** − 0.000001 × [Area of built-up blocks, 2008] **
Dependent Variable: Slope of Linear Trend of Producing Land Proportion Changes in Lithuanian Municipalities						
0.29	194.65	0.12	0.01	4.86	0.75	1.326413 − 0.025171 × [Minimum altitude] ** − 0.000049 × [Area of agricultural blocks, 2008] ** + 0.000042 × [Private land area, 2008] ** + 0.058605 × [Grassland, 2005] *** − 0.000001 × [Area of water bodies, 2008] **
Dependent Variable: Slope of Linear Trend of Grassland Proportion Changes in Lithuanian Municipalities						
0.50	140.2	0.56	0.37	4.66	0.13	4.202848 − 0.198318 × [Soil productivity grade] *** + 0.637596 × [Grassland area per cattle-unit, 2008] ** + 0.063401 × [Forest, 2005] *** − 0.000001 × [Length of streams, 2014] ** + 0.000001 × [Area of water bodies, 2014] **

Note: The statistical significance of each coefficient in the model is noted as follows: *, $p = 0.10$; **, $p = 0.05$; ***, $p = 0.01$.

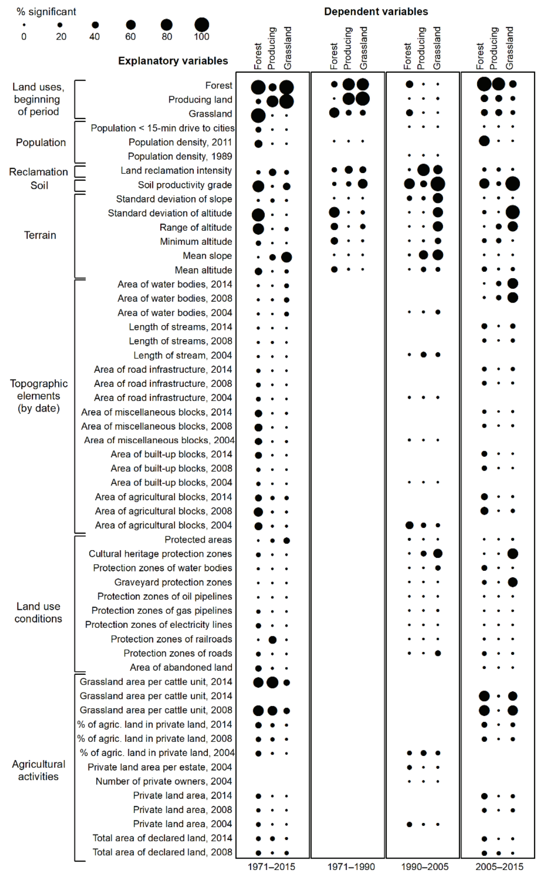

Figure 5. The proportions of times that each candidate explanatory variable was statistically significant when testing all potential regression models. Blank means that the variable was not included in the exploratory regression runs.

4. Discussion

The overall trend in Lithuania during the last five decades has been increases in the areas of forest and built-up lands and decreasing areas of producing land, meadow/pasture, wetlands, and other land uses. Nevertheless, the development trends for the proportions of producing land and meadow/pasture changed their trajectories several times. The breakpoints in the development of key agricultural land uses were linked with important dates in Lithuanian history. This suggests that the land-use development trends could be impacted by political processes in and around the land management and use relationships. Three periods were singled out with potentially differing land-use conditions. The first period (1971–1990) we associate with the development of large agricultural enterprises under the condition of a planned economy, as Lithuania was one of the former Soviet Union republics. Restructuring of agriculture started in 1991–1992. The reform of the national agrarian sector took place since the restoration of independence, which resulted in introducing private land ownership, together with changed overall principles of agriculture and land management. This was followed by a period of European Union and state budget support allocated to agriculture and rural development, since Lithuania joined the EU in 2004 [50–52]. The stable overall increase in forest could be explained by command-and-control forest governance restricting radical changes, strict deforestation control, and the aspiration to preserve domestic forest resources [22,53,54]. Thus, the trends observed in our study are associated, first of all, with political and social factors rather than natural conditions. This is supported by Ribokas and Milius [55], who argued that nearly all legal, economic, and social land management reforms in Lithuania were neither consistent nor unambiguous.

Even though Lithuania is a relatively small country with rather smoothly changing geographic conditions, we could still observe statistically significant patterns in the land-use distribution and changes. The increase in forest was largest in southwest Lithuania, potentially due to the fast increase during 1971–1990. Since 2005, however, forest increased the most in northeastern Lithuania and the hilly municipalities in the western part of the country. We explain this by the intensive afforestation of abandoned land or land not used for agriculture. The trajectories of producing land development were different during the periods analysed. If taking into consideration the last five decades, the overall decrease in producing land in the hilly areas of western and eastern Lithuania could be explained by the fast decrease in producing land in 1990–2005. These areas are less favourable for agriculture, and the presence of abandoned agricultural land is more common here. However, the development of producing land proportion was radically different in these areas during other periods, i.e., 1971–1990 and 2005–2015. Development trajectories of meadow/pasture were, at least in principle, the opposite to those of producing land. The most rapid reduction in meadow/pasture during the whole period analysed was in the flat central and northern municipalities with the most fertile soil for agriculture. The fastest decrease in meadow/pasture was seen here since 2005. Usually, producing land is converted into meadow/pasture, and vice versa. Similar changes were also noted by Aleknavičius [56], who reported that the area of producing land in Lithuania decreased by, on average, 18,900 ha annually in 1948–1989 and by even more—51,800 ha—during 1990–2005, with large areas of producing land converted into meadow/pasture. The total area of agricultural land was reported to have shrunk by 2.35% during 2007–2017 [57]. The decreasing area of agricultural land was explained by increasing forest and new housing areas, especially in hilly western regions [58,59]. The forest area of Lithuania is reported to have increased during the period since 1950 [41,60]. Usually, the largest increase in forest proportion is found in regions least favourable for agriculture. The largest areas of new forests emerged in southeastern Lithuania, while the slowest increase om forest was in the least forested municipalities. Some forest loss was also reported [41] since the 1950s, associated with forest transformation into agricultural land, or less frequently into scrubland or water bodies. The latter transformation was related with the construction of large artificial reservoirs. It should be noted that all of the national studies mentioned above, except for Juknelienė and Mozgeris [41], did not use spatial statistics to support their findings on land-use distribution patterns. Similar forest and agricultural land changes were reported in neighbouring countries, e.g., in Poland [61].

The available land use and land-use change patterns are usually associated with interactions between socioeconomic and cultural land management conditions, biophysical constraints, and land-use history [62]. To specify the interactions, we have chosen the multiple regression. Our focus in the current study was on the characterization—or, at least, identification—of the most important biophysical and socioeconomic drivers of land use in Lithuania. Usually, the candidate drivers are suggested based on a literature review and expert knowledge. We introduced one extra criterion: the driver needs to be described using easily available data. In addition to census data, we gathered study information available from the Spatial Information Portal of Lithuania. The majority of such spatial information was captured during the last few decades; thus, this could have impacts on the performance of the regression models developed for the earlier periods covered in our study. The best regression model, in terms of R^2, was developed to explain the changes in forest proportion during the whole period (i.e., 1971–2015). However, the development of forest was very smooth during the whole period. Shorter periods resulted in better performance of the regression models if modelling the proportion changes of meadow/pasture and, partly, the proportion of producing land. In all cases, the Akaike Information Criterion values for models with a shorter time period were higher than those for the land-use change from 1971 to 2015. In addition to the availability and quality of historical explanatory driver variables, multiple regression in land-use change analyses can be used for relatively short time periods, i.e., one or two decades [63]. We should also emphasise that we did not aim to elaborate the overall best regression models, i.e., the focus was on testing all potential driver variables in all potential combinations, taking into consideration, of course, the statistical significance and multicollinearity of factors and properties of model residuals.

If taking a closer look at the performance of each tested candidate driver variable, the importance of the forest proportion at the beginning of each period stands out. We could consider the abundance of forest in the municipality as a key indicator of landscape stability [64]. In 2019 forest covered 33.7% of Lithuania [60], and a political objective was set to increase this figure to at least 35% by the year 2030 [65]. Assuming that the annual forest area increase rate during the period from 1971 until 2015 was 0.085% (0.108% during the last decade), this objective could be achieved by increasing the country's forest area by at least 0.118% per year. This challenging task would impact the development of other land uses, both considering the models suggested in the current study and the practice of afforesting abandoned or unsuitable agricultural land [65]. We identified the soil productivity grade as an important factor shaping land-use changes, even though there was some scepticism regarding using the crop production potential of the land for exploring land-use change patterns [66,67]. Soil productivity grade was most strongly correlated with the change trends of producing land and meadow/pasture proportion (Table 3). It was a statistically significant contributor in models explaining, e.g., forest changes (the factor was significant in 69% and 61% of all cases tested for the periods 1990–2005 and 2005–2015, respectively) and grassland changes (98% and 97%). Population is usually reported as an important factor influencing land-use distribution [68–74]. We did not directly use the statistics on, e.g., the ratio between the urban and rural population; however, we integrated the factors that were used to specify the rural population in the recent FP7 RURALJOBS project [47]. However, neither population density nor the share of population within a specified driving distance of cities was found to be among the most important factors. The reason could also be the reference date of the population data—e.g., the population density in 2011 was a significant factor in nearly 70% of cases tested to describe forest area changes after 2005. Land reclamation is considered an important factor that has been shaping Lithuanian landscapes in the second half of the 20th century [75–77]. It should be emphasized that the facilities available for land reclamation in Lithuania influence the land use—e.g., afforestation of agricultural lands, is dependent on the presence or absence of land with a functioning land reclamation system [78]. In our study, the intensity of land reclamation in the municipality is an important factor for explaining changes in producing land and meadow/pasture. The topography of the landscape is usually closely related to the land use and land-use change patterns [62,79,80]. However, this attribute is scale-dependent; thus, relatively coarse-scale elevation data sources were used to reveal the general trends. Even though Lithuania can be characterised as a lowland country (cf. Figure 1), there are differences in the land use and land-use change patterns observed between the hilly and relatively flat municipalities. Topography-related factors are, therefore, more effective at explaining changes in agricultural land. In Lithuanian municipalities, the soil productivity is inversely correlated with the average altitude ((Pearson's correlation coefficient −0.579 (N = 51))), slope steepness (Pearson's correlation coefficient −0.552 (N = 51)), and diversity of elevation conditions, expressed as a standard deviation of altitude (Pearson's correlation coefficient −0.333 (N = 51)) or slope steepness (Pearson's correlation coefficient −0.510 (N = 51)). The land-use change transitions usually involve conversion from producing land into meadow and pasture or vice versa, usually on land less suitable for growing crops.

Table 3. Pearson's correlation coefficient between a selected explanatory variable and the slope of the linear trend in the development of a specific land-use proportion over a certain period ($N = 51$).

Selected Explanatory Variable	Forest				Producing Land				Meadow/Pasture			
	1971–2015	1971–1990	1990–2005	2005–2015	1971–2015	1971–1990	1990–2005	2005–2015	1971–2015	1971–1990	1990–2005	2005–2015
Soil productivity grade	−0.347	−0.247	−0.202	−0.337	0.314	−0.427	0.408	−0.175	−0.407	0.609	−0.520	−0.580
Population density in 2011	−0.295	−0.117	−0.284	−0.384	0.064	−0.047	0.014	−0.014	−0.135	0.067	−0.094	−0.061
Land reclamation intensity	−0.091	−0.216	0.032	−0.178	0.426	−0.511	0.502	0.006	−0.364	0.506	−0.398	−0.387
Standard deviation of altitude	0.421	0.474	0.009	−0.043	−0.033	0.132	−0.134	0.117	0.121	−0.332	0.365	0.441
Mean slope	0.123	0.298	−0.015	0.025	−0.458	0.393	−0.410	0.096	0.409	−0.450	0.420	0.306
Forest	−0.499	−0.259	−0.106	−0.121	−0.231	0.136	0.567	−0.037	0.127	−0.270	−0.590	0.049
Producing land	−0.130	−0.094	−0.118	−0.257	0.468	−0.290	0.572	−0.079	−0.512	0.348	−0.628	−0.628
Grassland	0.577	0.551	0.397	0.424	−0.385	0.042	−0.541	0.185	0.515	0.016	0.597	0.623

5. Conclusions

The annual land-use changes in Lithuanian municipalities were identified for the period 1971–2015 using sampling-based information from the Lithuanian National Forest Inventory. Originally developed to support strategic forest planning with data, the Lithuanian NFI was recently adopted to monitor land-use changes. We demonstrate its usability to explore land use and land-use change properties. Lithuania, being a relatively small lowland country, exhibits statistically significant spatial patterns in land use and land-use change distribution. Since 1971, the area of land uses important for carbon storage (forest, producing land, and meadow/pasture) was similar—20–37% each. Since then, the proportion of producing land, forest, and built-up areas did increase, while the proportions of meadows and pastures, wetlands, and other lands went down. The area of forest, wetlands, built-up areas, and other land changed relatively steadily over the last five decades. However, the trends of changes in producing land and meadow/pasture depended on the historical period, being associated with historical periods impacted by political processes in and around land management and use relationships. The proportions of producing land and pasture/meadow remained spatially autocorrelated during the whole period analysed. Local spatial clusters and outliers were identified for all land-use types at each time point analysed, suggesting the need for spatially explicit land-use management policies.

Exploiting the information from publicly available GIS and agricultural census databases, we managed to explain, using multiple linear regression, up to 65% of the variance in forest, 40% in producing land, and 37% in meadow/pasture proportion changes over the entire period of 1971–2015. The regression models usually improved with shorter time periods for producing land and meadow/pasture proportion changes. Usually, the factors shaping the changes in the proportions of forest and meadow/pasture were similar, but different from those affecting producing land changes. We associated the trends in land-use changes and the models explaining them with the interactions of political, natural, and social systems.

We also conclude that a spatially explicit assessment of the land-use pattern can identify critical areas of land-use change and give insight to improve land management policies and associated decisions. More specifically, in order to increase carbon absorption, it is necessary to know the processes involved in the development of land surface layers and land use and to have solutions in hand to manage these processes. This can be achieved by assessing land-use development in Lithuania, with particular attention to the determinants of land use, understanding methodological principles for land-use development modelling. Wall-to-wall maps of land uses, developed at the compatible spatial and temporal resolutions using data in the Lithuanian National Forest Inventory, could help to improve both the evaluation of land-use status and the prediction of changes.

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Appendix A

Table A1. Factors used to model land-use development.

Factor Name	Description	Date *	Source
Population density, 1989	Population density in 1989, number of inhabitants/km^2	1989	Population and housing census 1989
Population density, 2011	Population density in 2011, number of inhabitants/km^2	2011	Population and housing census 2011
Soil productivity grade	Average soil productivity score for agricultural land		Dirv_DR10LT—spatial dataset of soil of the territory of the Republic of Lithuania at scale 1:10,000
Land reclamation intensity	Drainage areas from the total area of the municipality, percentage		Mel_DR10LT—spatial dataset of reclamation status and sodden soil of the territory of the Republic of Lithuania at scale 1:10,000
Minimum altitude	Minimum altitude value within the borders of municipality		Digital raster elevation model (cell size 100 m) in GDB200 GIS database—topographic map at scale 1:200,000. Elevation model was created using contour lines (interval between contours 20 m) and elevation points and applying Topo to Raster function of ArcGIS Desktop
Range of altitude	Range of altitude values within the borders of municipality		
Mean altitude	The average altitude within the borders of municipality		
Standard deviation of altitude	Standard deviation of altitude values within the borders of municipality		
Mean slope	Average of terrain slope within the borders of municipality. Slope was calculated in degrees using Slope function of ArcGIS Desktop		
Standard deviation of slope	Standard deviation of relief slope values within the borders of municipality.		
Private land area, 2004	Private land area in 2004	2004	Agricultural census data, available from the Official Statistics Portal of Lithuania
Number of private owners, 2004	Number of private owners in 2004	2004	
Private land area per estate, 2004	Average area of private land area per estate in 2004	2004	
% of agricultural land in private land, 2004	Proportion of agricultural land in private land area in 2004	2004	
Private land area, 2008	Private land area in 2008	2008	
Number of private owners, 2008	Number of private owners in 2008	2008	
Private land area per estate, 2008	Average area of private land area per estate in 2008	2008	
% of agricultural land in private land, 2008	Proportion of agricultural land in private land area in 2008	2008	
Private land area, 2014	Private land area in 2014	2014	
Number of private owners, 2014	Number of private owners in 2014	2014	
Private land area per estate, 2014	Average area of private land area per estate in 2014	2014	
% of agricultural land in private land, 2014	Proportion of agricultural land in private land area in 2014	2014	

Table A1. *Cont.*

Factor Name	Description	Date *	Source
Grassland area per cattle-unit, 2008	Area of permanent pasture for one animal unit in 2008	2008	
Grassland area per cattle-unit, 2014	Area of permanent pasture for one animal unit in 2014	2014	
Forest, 1971	Proportion of forest area in municipality in 1971	1971	Database of Lithuanian NFI
Forest, 1990	Proportion of forest area in municipality in 1990	1990	
Forest, 2005	Proportion of forest area in municipality in 2005	2005	
Forest, 2015	Proportion of forest area in municipality in 2015	2015	
Producing land, 1971	Proportion of producing land area in municipality in 1971	1971	
Producing land, 1990	Proportion of producing land area in municipality in 1990	1990	
Producing land, 2005	Proportion of producing land area in municipality in 2005	2015	
Producing land, 2015	Proportion of producing land area in municipality in 2015	2015	
Grassland, 1971	Proportion of grassland area in municipality in 1971	1971	
Grassland, 1990	Proportion of grassland area in municipality in 1990	1990	
Grassland, 2005	Proportion of grassland area in municipality in 2005	2005	
Grassland, 2015	Proportion of grassland area in municipality in 2015	2015	
Population < 15-min drive to cities	Proportion of population residing within 15 min driving distance to cities	2007	Cartographic vector database of reference features according to the national specification KDB10LT-MIKRO (earlier version of current Georeference background cadastre (GRPK)), with all field and forest roads from Forest State Cadastre additionally included
Protection zones of roads	Area of protection zones around roads		SŽNS_DR10LT—data base of limited land-use areas of the Republic of Lithuania at scale 1:10,000
Protection zones of railroads	Area of protection zones around railroads		
Protection zones of electricity lines	Area of protection zones around electricity lines		
Protection zones of gas pipelines	Area of protection zones around gas pipelines		
Protection zones of oil pipelines	Area of protection zones around oil pipelines		
Graveyard protection zones	Area of graveyards and protection zones around them		

Table A1. *Cont.*

Factor Name	Description	Date *	Source
Protection zones of water bodies	Area of protection zones around water bodies		
Cultural heritage protection zones	Area of cultural heritage protection zones		
Protected areas	Total area of protected areas		
Area of abandoned land	Total area of abandoned agricultural land		AŽ_DRLT—spatial dataset of neglected land of the territory of the Republic of Lithuania
Area of agricultural blocks, 2004	Area of agricultural blocks in municipality in 2004	2004	Land parcel identification system (KZS_DR5LT) database and cartographic vector database of reference features according to the national specification KDB10LT-MIKRO or (for 2014) Georeference background cadastre (GRPK)
Area of built-up blocks, 2004	Area of built-up blocks in municipality in 2004	2004	
Area of miscellaneous blocks, 2004	Area of miscellaneous blocks in municipality in 2004	2004	
Area of road infrastructure	Area of road blocks in municipality in 2004	2004	
Length of streams, 2004	Total length of streams in municipality in 2004	2004	
Area of water bodies, 2004	Area of blocks around the water bodies in municipality in 2004	2004	
Area of agricultural blocks, 2008	Area of agricultural blocks in municipality in 2008	2008	
Area of built-up blocks, 2008	Area of built-up blocks in municipality in 2008	2008	
Area of miscellaneous blocks, 2008	Area of miscellaneous blocks in municipality in 2008	2008	
Area of road infrastructure, 2008	Area of road blocks in municipality in 2008	2008	
Length of streams, 2008	Total length of streams in municipality in 2008	2008	
Area of water bodies, 2008	Area of blocks around the water bodies in municipality in 2008	2008	
Area of agricultural blocks, 2014	Area of agricultural blocks in municipality in 2014	2014	
Area of built-up blocks, 2014	Area of built-up blocks in municipality in 2014	2014	
Area of miscellaneous blocks, 2014	Area of miscellaneous blocks in municipality in 2014	2014	
Area of road infrastructure, 2014	Area of road blocks in municipality in 2014	2014	
Length of streams, 2014	Total length of streams in municipality in 2014	2014	
Area of water bodies, 2014	Area of blocks around the water bodies in municipality in 2014	2014	

* If no date is specified, the latest version of the relevant database was used.

References

1. Lambin, E.F.; Meyfroidt, P. Global land use change, economic globalization, and the looming land scarcity. *Proc. Natl. Acad. Sci. USA* **2011**, *108*, 3465–3472. [CrossRef] [PubMed]
2. Song, X.-P.; Hansen, M.C.; Stehman, S.V.; Potapov, P.V.; Tyukavina, A.; Vermote, E.F.; Townshend, J.R. Global land change from 1982 to 2016. *Nature* **2018**, *560*, 639–643. [CrossRef] [PubMed]
3. Goldewijk, K.K.; Ramankutty, N. Land cover change over the last three centuries due to human activities: The availability of new global data sets. *Geojournal* **2004**, *61*, 335–344. [CrossRef]
4. Van Asselen, S.; Verburg, P.H. Land cover change or land-use intensification: Simulating land system change with a global-scale land change model. *Glob. Chang. Biol.* **2013**, *19*, 3648–3667. [CrossRef]
5. Liu, S.; Gao, W.; Liang, X.-Z. A regional climate model downscaling projection of China future climate change. *Clim. Dyn.* **2013**, *41*, 1871–1884. [CrossRef]
6. Lawler, J.J.; Lewis, D.J.; Nelson, E.; Plantinga, A.J.; Polasky, S.; Withey, J.C.; Helmers, D.P.; Martinuzzi, S.; Pennington, D.; Radeloff, V.C. Projected land-use change impacts on ecosystem services in the United States. *Proc. Natl. Acad. Sci. USA* **2014**, *111*, 7492–7497. [CrossRef]
7. Spera, S.A.; Galford, G.L.; Coe, M.T.; Macedo, M.N.; Mustard, J.F. Land-use change affects water recycling in Brazil's last agricultural frontier. *Glob. Chang. Biol.* **2016**, *22*, 3405–3413. [CrossRef] [PubMed]
8. Borrelli, P.; Robinson, D.A.; Fleischer, L.R.; Lugato, E.; Ballabio, C.; Alewell, C.; Meusburger, K.; Modugno, S.; Schütt, B.; Ferro, V.; et al. An assessment of the global impact of 21st century land use change on soil erosion. *Nat. Commun.* **2017**, *8*, 1–13. [CrossRef]
9. Hostert, P.; Kuemmerle, T.; Prishchepov, A.; Sieber, A.; Lambin, E.F.; Radeloff, V.C. Rapid land use change after socio-economic disturbances: The collapse of the Soviet Union versus Chernobyl. *Environ. Res. Lett.* **2011**, *6*. [CrossRef]
10. Wu, J.; Hobbs, R. Key issues and research priorities in landscape ecology: An idiosyncratic synthesis. *Landsc. Ecol.* **2002**, *17*, 355–365. [CrossRef]
11. Serra, P.; Pons, X.; Sauri, D. Post-classification change detection with data from different sensors: Some accuracy considerations. *Int. J. Remote Sens.* **2003**, *24*, 3311–3340. [CrossRef]
12. Zhang, F.; Tiyip, T.; Feng, Z.D.; Kung, H.; Johnson, V.C.; Ding, J.L.; Tashpolat, N.; Sawut, M.; Gui, D.W. Spatio-Temporal Patterns of Land Use/Cover Changes Over the Past 20 Years in the Middle Reaches of the Tarim River, Xinjiang, China. *Land Degrad. Dev.* **2015**, *26*, 284–299. [CrossRef]
13. Bell, A.R.; Ward, P.S.; Mapemba, L.; Nyirenda, Z.; Msukwa, W.; Kenamu, E. Smart subsidies for catchment conservation in Malawi. *Sci. Data* **2018**, *5*, 180113. [CrossRef] [PubMed]
14. Dale, V.; O'Neill, R.; Pedlowski, M.; Southworth, F. Causes and effects of land use change in Central Rondonia, Brazil. *Photogramm. Eng. Remote Sens.* **1993**, *59*, 97–1005.
15. Houghton, R.A. The world-wide extent of land-use change. *Bioscience* **1994**, *44*, 305–313. [CrossRef]
16. Medley, K.E.; Okey, B.W.; Barrett, G.W.; Lucas, M.F.; Renwick, W.H. Landscape change with agricultural intensification in a rural watershed, southwestern Ohio, USA. *Landsc. Ecol.* **1995**, *10*, 161–176. [CrossRef]
17. Tsendbazar, N.; Herold, M.; Lesiv, M.; Fritz, S. *Copernicus Global Land Operations—Vegetation and Energy "CGLOPS-1"*; European Union: Brussels, Belgium, 2018.
18. Schäfer, M.P.; Dietrich, O.; Mbilinyi, B. Streamflow and lake water level changes and their attributed causes in Eastern and Southern Africa: State of the art review. *Int. J. Water Resour. Dev.* **2015**, *32*, 853–880. [CrossRef]
19. Gessesse, B.; Bewket, W.; Bräuning, A. Model-Based Characterization and Monitoring of Runoff and Soil Erosion in Response to Land Use/land Cover Changes in the Modjo Watershed, Ethiopia. *Land Degrad. Dev.* **2015**, *26*, 711–724. [CrossRef]
20. Ligonja, P.J.; Shrestha, R.P. Soil Erosion Assessment in Kondoa Eroded Area in Tanzania using Universal Soil Loss Equation, Geographic Information Systems and Socioeconomic Approach. *Land Degrad. Dev.* **2015**, *26*, 367–379. [CrossRef]
21. Lithuanian Statistical Yearbook. National Land Service under the Ministry of Agriculture of the Republic of Lithuania. 2000. Available online: http://www.nzt.lt/go.php/lit/Lietuvos-respublikos-zemes-fondas (accessed on 14 January 2021).
22. Mozgeris, G.; Juknelienė, D. Modeling Future Land Use Development: A Lithuanian Case. *Land* **2021**, *10*, 360. [CrossRef]
23. Veteikis, D.; Piškinaitė, E. Geographical study of land use Change in Lithuania: Development, directions, perspectives. *Geol. Geogr.* **2019**, *5*. [CrossRef]
24. European Landscape Convention. Strasbourg. 2000. Available online: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.189933 (accessed on 9 February 2021).
25. Ribokas, G. Apleistų žemių (dirvonų) problema retai apgyvendintose teritorijose [Problem of Unused Lands in the Sparsely Populated Regions]. *Kaimo Raidos Kryptys Žinių Visuomenėje* **2011**, *2*, 298–307.
26. Vaitkus, G. *CORINE Žemės Danga 2000 Lietuvoje*; Aplinkos Apsaugos Agentūra prie LR Aplinkos Ministerijos: Vilnius, Lithuania, 2004.
27. Vaitkus, G. *Lietuvos CORINE Žemės Danga GIS Duomenų Bazės Taikomojo Panaudojimo Aplinkosaugos Srityje Studija*; Sutarties Nr.4F–124 (2004.08.27); Aplinkos Apsaugos Agentūra Prie LR Aplinkos Ministerijos: Vilnius, Lithuania, 2005.
28. Vaitkuviene, D.; Dagys, M. *Lietuvos CORINE Žemσs Danga 2006*; Vilniaus Universiteto Ekologijos Instituto GIS Grupė, Aplinkos Apsaugos Agentnūros Užsakymu: Vilnius, Lithuania, 2008.

29. Vitkauskienė, R.; Antanavičiūtė, U.; Buiko, A.; Kasilovskis, K.S.; Jelisejev, A.; Pakrosnienė, I. *GMES Žemės Dangos Monitoringas 2011–2013 m*; Lietuvos CORINE Žemės Dangos Duomenų Bazės ir Tematinių Sluoksnių Parengimas; Sutarties Nr. 28TP-2013-73/(4.22)10MF-63; GIS-Centras ir Aerogeodezijos Institutas: Vilnius, Lithuania, 2014.
30. Flynn, H.C.; Canals, L.M.I.; Keller, E.; King, H.; Sim, S.; Hastings, A.; Wang, S.; Smith, P. Quantifying global greenhouse gas emissions from land-use change for crop production. *Glob. Chang. Biol. Bioenergy* **2012**, *18*, 1622–1635. [CrossRef]
31. Richards, M.; Pogson, M.; Dondini, M.; Jones, E.O.; Hastings, A.; Henner, D.N.; Tallis, M.J.; Casella, E.; Matthews, R.W.; Henshall, P.A.; et al. High-resolution spatial modelling of greenhouse gas emissions from land-use change to energy crops in the United Kingdom. *GCB Bioenergy* **2016**, *9*, 627–644. [CrossRef]
32. Smith, P.; Adams, J.; Beerling, D.J.; Beringer, T.; Calvin, K.V.; Fuss, S.; Griscom, B.; Hagemann, N.; Kammann, C.; Kraxner, F.; et al. Land-Management Options for Greenhouse Gas Removal and Their Impacts on Ecosystem Services and the Sustainable Development Goals. *Annu. Rev. Environ. Resour.* **2019**, *44*, 255–286. [CrossRef]
33. Blujdea, V.N.; Bird, D.N.; Robledo, C. Consistency and comparability of estimation and accounting of removal by sinks in afforestation/reforestation activities. *Mitig. Adapt. Strat. Glob. Chang.* **2009**, *15*, 1–18. [CrossRef]
34. Fyson, C.L.; Jeffery, M.L. Ambiguity in the Land Use Component of Mitigation Contributions Toward the Paris Agreement Goals. *Earth's Future* **2019**, *7*, 873–891. [CrossRef]
35. Konstantinavičiūtė, I.; Byčenkienė, S.; Kavšinė, A.; Zaikova, I.; Juška, R.; Žiukelytė, I.; Lenkaitis, R.; Kazanavičiūtė, V.; Mačiulskas, M.; Juraitė, T.; et al. *Lithuania's National Inventory Report 2018: Greenhouse Gas Emissions 1990–2016*; Ministry of Environment, Environmental Protection Agency, State Forest Service: Vilnius, Lithuania, 2018; p. 617. Available online: http://klimatas.gamta.lt/files/LT_NIR_20180415_final.pdf (accessed on 9 February 2021).
36. Kulbokas, G.; Jurevičienė, V.; Kuliešis, A.; Augustaitis, A.; Petrauskas, E.; Mikalajūnas, M.; Vitas, A.; Mozgeris, G. Fluctuations in gross volume increment estimated by the Lithuanian National Forest Inventory compared with annual variations in single tree increment. *Balt. For.* **2019**, *25*, 105–112. [CrossRef]
37. Lukšienė, L. *Pasėlių, pievų, pelkių, urbanizuotų teritorijų ir kitų žemės naudmenų plotų pokyčių Lietuvoje 1990–2011 m. įvertinimas [Assessment of Producing Land, Grassland, Wetland, Urban Land and Other Land Use Changes in Lithuania during 1990–2011]; Darbo pagal 2012 m. kovo 8 d. sutarties Nr. 2012.03.18-001 tarp Lietuvos Respublikos aplinkos ministerijos ir VĮ Valstybės žemės fondo ataskaita [Report of the Project Implemented following the Agreement from 8 March 2012 No.2012.03.18-001 between Ministry of Environment of Republic of Lithuania and State Company Valstybinės Žemės Fondas)*; Lietuvos Respublikos Aplinkos Ministerija: Vilnius, Lithuania, 2012; p. 13. (In Lithuanian)
38. Longley, P.A.; Goodchild, M.F.; Maguire, D.J.; Rhind, D.W. *Geographic Information Science and Systems*, 4th ed.; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2015; p. 496.
39. Kučas, A.; Trakimas, G.; Balčiauskas, L.; Vaitkus, G. Multi-scale Analysis of Forest Fragmentationin Lithuania. *Balt. For.* **2011**, *17*, 128–135.
40. Lazdinis, M.; Roberge, J.M.; Mozgeris, G.; Angelstam, P. Afforestation planning and biodiversity conservation: Predicting effects on habitat functionality in Lithuania. *J. Environ. Plan. Manag.* **2005**, *48*, 331–348. [CrossRef]
41. Jukneliene, D.; Mozgeris, G. The spatial pattern of forest cover changes in Lithuania during the second half of the twentieth century. *Žemės Ūkio Mokslai* **2015**, *22*, 209–215. [CrossRef]
42. Manton, M.; Makrickas, E.; Banaszuk, P.; Kołos, A.; Kamocki, A.; Grygoruk, M.; Stachowicz, M.; Jarašius, L.; Zableckis, N.; Sendžikaitė, J.; et al. Assessment and Spatial Planning for Peatland Conservation and Restoration: Europe's Trans-Border Neman River Basin as a Case Study. *Land* **2021**, *10*, 174. [CrossRef]
43. Tiškutė-Memgaudienė, D.; Mozgeris, G.; Gaižutis, A. Open geo-spatial data for sustainable forest management: Lithuanian case. *For. Wood Process.* **2020**. [CrossRef]
44. Juknelienė, D.; Valčiukienė, J.; Atkocevičienė, V. Assessment of regulation of legal relations of territorial planning: A case study in Lithuania. *Land Use Policy* **2017**, *67*, 65–72. [CrossRef]
45. Kuliešis, A.; Kasperavičius, A.; Kulbokas, G. *Lithuania (Book Chapter) National Forest Inventories: Assessment of Wood Availability and Use*; Springer: Cham, Switzerland, 2016; pp. 521–547.
46. IPCC. *Good Practice Guidancefor Land Use, Land-Use Change and Forestry*; National Greenhouse Gas Inventories Programme; C/o Institute for Global Environmental Strategies 2108-11; Institute for Global Environmental Strategies: Hayama, Japan, 2003; p. 240-0115.
47. FP7 RURALJOBS Project. Available online: https://cordis.europa.eu/project/id/211605/reporting (accessed on 22 February 2021).
48. Official Statistics Portal of Lithuania. Available online: https://osp.stat.gov.lt/zemes-ukio-surasymai1 (accessed on 22 February 2021).
49. Salmi, T.; Anu Määttä, A.; Anttila, P.; Ruoho-Airola, T.; Amnell, T. *Detecting Trends of Annual Values of Atmospheric Pollutants by the Mann-Kendall Test and Sen's Slope Estimates—The Excel Template Application MAKESENS*; No. 31, Report Code FMI-AQ-31; Finnish Meteorological Institute, Air Quality Research, Publications on Air Quality: Helsinki, Finland, 2002; 35p, Available online: https://www.researchgate.net/publication/259356944 (accessed on 9 December 2018).
50. Lietuvos 2007–2013 m. Kaimo Plėtros Programa [Rural Development Programme 2007–2013]. Europos Komisija, 2007 m. Rugsėjo 19 d. Nr. 1698/2005. Available online: https://zum.lrv.lt/uploads/zum/documents/files/LT_versija/Veiklos_sritys/Kaimo_pletra/Lietuvos_kaimo_pletros_2007%E2%80%932013%20m._programa/KPP20072013LT20141222.pdf (accessed on 22 January 2021).

51. Lietuvos 2014–2020 m. Kaimo Plėtros Programa [Rural Development Programme 2014–2020]. Europos Komisija, 2015 m. Vasario 13 d. Nr. C(2015)842. Available online: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/rdp-lithuanua-fulltext_lt.pdf (accessed on 22 January 2021).
52. European Parliament and Council. Regulation (EU) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 Establishing Rules for Direct Payments to Farmers under Support Schemes within the Framework of the Common Agricultural Policy and Repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009. Available online: http://data.europa.eu/eli/reg/2013/1307/oj (accessed on 14 January 2021).
53. Makrickiene, E.; Mozgeris, G.; Brukas, V.; Brodrechtova, Y.; Sedmak, R.; Salka, J. From command-and-control to good forest governance: A critical comparison between Lithuania and Slovakia. *For. Policy Econ.* **2019**, *109*, 1–13. [CrossRef]
54. Mozgeris, G.; Kazanavičiūtė, V.; Jukneliene, D. Does Aiming for Long-Term Non-Decreasing Flow of Timber Secure Carbon Accumulation: A Lithuanian Forestry Case. *Sustainability* **2021**, *13*, 2778. [CrossRef]
55. Ribokas, G.; Milius, J. Turning point in the development of farm lands (a case of Lithuanian agroterritories). *Geografija* **2007**, *43*, 8–11.
56. Aleknavičius, P. Kaimiškųjų teritorijų žemės naudojimo problemos [Land use problems in rural territories]. *Žemės Ūkio Mokslai* **2007**, *14*, 82–90.
57. Gerulytė, P.; Stravinskienė, V. Žemės ūkio naudmenų kaita Lietuvos ir Europos agrarinėse teritorijose [The change of agricultural lands in the agrarian areas of Lithuania and Europe]. *Miškininkystė ir Kraštotvarka. Kauno Miškų ir Aplink. Inžinerijos Kolegija* **2017**, *2*, 95–99.
58. Aleknavičius, P.; Valčiukienė, J. Kaimiškojo kraštovaizdžio raidos ypatumai Vilniaus miesto įtakos zonoje. *Vandens Ūkio Inžinerija* **2011**, *38*, 32–41.
59. Aleknavičius, P.; Aleknavičius, A.; Juknelienė, D. Agrarinių teritorijų naudojimo problemos ir jų sprendimas Lietuvoje [Problems and solutions of the use of agrarian areas in Lithuania]. *Žemės Ūkio Mokslai* **2014**, *2*, 78–88.
60. Lithuanian Statistical Yearbook of Forestry. Ministry of Environment, State Forest Service. 2019. Available online: http://www.amvmt.lt/index.php/leidiniai/misku-ukio-statistika/2019 (accessed on 14 January 2021).
61. Kurowska, K.; Kryszk, H.; Marks-Bielska, R.; Mika, M.; Leń, P. Conversion of agricultural and forest land to other purposes in the context of land protection: Evidence from Polish experience. *Land Use Policy.* **2020**, *95*, 104614. [CrossRef]
62. Verburg, P.; de Koning, G.; Kok, K.; Veldkamp, A.; Bouma, J. A spatial explicit allocation procedure for modelling the pattern of land use change based upon actual land use. *Ecol. Model.* **1999**, *116*, 45–61. [CrossRef]
63. Veldkamp, A.; Fresco, L.O. Reconstructing land use drivers and their spatial scale dependence for Costa Rica (1973 and 1984). *Agric. Syst.* **1997**, *55*, 19–43. [CrossRef]
64. Vinclovaitė, G.; Veteikis, D. Kraštovaizdžio poliarizacijos metodologinės problemos [The problems of landscape polarization methodology]. *Geografja* **2011**, *47*, 38–45.
65. Lietuvos Respublikos Teritorijos Bendrasis Planas [Plan of the Territory of the Republic of Lithuania]. Available online: http://www.bendrasisplanas.lt/wp-content/uploads/2020/07/LR-BPTeritorini%C5%B3-element%C5%B3-vystymas.pdf (accessed on 14 January 2021).
66. Veldkamp, A.; Zuidema, G.; Fresco, L.; Veldkamp, T. A model analysis of the terrestrial vegetation model of image 2.0 for Costa Rica. *Ecol. Model.* **1996**, *93*, 263–273. [CrossRef]
67. Veldkamp, A.; Fresco, L. Exploring land use scenarios, an alternative approach based on actual land use. *Agric. Syst.* **1997**, *55*, 1–17. [CrossRef]
68. Bilsborrow, R.E.; Okoth-Ogendo, H.W.O. Population-Driven Changes in Land Use in Developing Countries. *Ambio* **1992**, *21*, 37–45.
69. Heilig, G.K. Neglected Dimensions of Global Land-Use Change: Reflections and Data. *Popul. Dev. Rev.* **1994**, *20*, 831. [CrossRef]
70. Azadi, H.; Ho, P.; Hasfiati, L. Agricultural land conversion drivers: A comparison between less developed, developing and developed countries. *Land Degrad. Dev.* **2010**, *22*, 596–604. [CrossRef]
71. Chen, R.S.; Ye, C.; Cai, Y.L.; Xing, X.S.; Chen, Q. The impact of rural out-migration on land use transition in China: Past, present and trend. *Land Use Policy* **2014**, *40*, 101–110. [CrossRef]
72. Skog, K.L.; Steinnes, M. How do centrality, population growth and urban sprawl impact farmland conversion in Norway? *Land Use Policy* **2016**, *59*, 185–196. [CrossRef]
73. Haarsma, D.; Qiu, F. Assessing Neighbor and Population Growth Influences on Agricultural Land Conversion. *Appl. Spat. Anal. Policy* **2017**, *10*, 21–41. [CrossRef]
74. Tong, Q.; Qiu, F. Population growth and land development: Investigating the bi-directional interactions. *Ecol. Econ.* **2020**, *169*, 106505. [CrossRef]
75. Maziliauskas, A.; Morkunas, V.; Rimkus, Z.; Šaulys, V. Economic incentives in land reclamation sector in Lithuania. *J. Water Land Dev.* **2007**, *11*, 17–30. [CrossRef]
76. Mardosa, J. Lithuania's Rural Settlements Structural Transformations in Soviet and Post-Soviet Period. In *Liquid Structures and Cultures*; Uniwersytet Szczeciński: Szczecin, Poland, 2017.
77. Šaulys, V.; Barvidienė, O. Substantiation of the expediency of drainage systems renovation in Lithuania. In Proceedings of the 9th International Conference Environmental Engineering, Vilnius, Lithuania, 22–23 May 2014. [CrossRef]

78. Lietuvos Respublikos Žemės ūkio Ministro ir Lietuvos Respublikos Aplinkos Ministro į s a k y m a s dėl Miško Įveisimo ne Miško Žemėje 2004 m. kovo 29 d. Nr. 3D-130/D1-144 Vilnius. Available online: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.230808/asr (accessed on 22 February 2021).
79. Johnson, G.D.; Patil, G.P. *Landscape Pattern Analysis for Assessing Ecosystem Condition*; Springer: Boston, MA, USA, 2006.
80. Zhao, Y.; Tomita, M.; Hara, K.; Fujihara, M.; Yang, Y.; Da, L. Effects of topography on status and changes in land-cover patterns, Chongqing City, China. *Landsc. Ecol. Eng.* **2011**, *10*, 125–135. [CrossRef]

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Article

Modeling Future Land Use Development: A Lithuanian Case

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Abstract: Effective management decisions regarding greenhouse gas (GHG) emissions may be hampered by the lack of scientific tools for modeling future land use change. This study addresses methodological principles for land use development scenario modeling assumed for use in processes of GHG accounting and management. Associated land use policy implications in Lithuania are also discussed. Data on land uses, available from the National Forest Inventory (NFI) and collected for GHG accounting from the land use, land use change and forestry (LULUCF) sector in the country, as well as freely available geographic information, were tested as an input for modeling land use development in the country. The modeling was implemented using the TerrSet Land Change Modeler. Calibration of the modeling approach using historical land use data indicated that land use types important for GHG management in the LULUCF sector were predicted with an accuracy above 80% during a five-year period into the future, while the prediction accuracy for forest and built-up land was 96% or more. Based on several land management scenarios tested, it was predicted that the LULUCF sector in Lithuania will accumulate CO_2, with the forest land use type contributing most to CO_2 absorption. Key measures to improve the GHG balance and carbon stock changes were suggested to be the afforestation of abandoned or unused agricultural land and prevention of the conversion of grassland into producing land.

Keywords: land use; land use change; scenario; carbon stock changes; simulation; forest; producing land; grassland

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1. Introduction

Substances of anthropogenic origin have a major influence on the climate system [1]. Human economic activity contributes to thermal atmospheric pollution—increasing greenhouse gas (GHG) concentration enlarges the natural greenhouse effect and plays a decisive role in the rise of the average global temperature [2–4]. GHGs are mainly generated by the combustion of fossil fuels in industrial and agricultural production processes, and, by a large proportion, from waste [3,5–9]. GHG absorption is usually associated with the physiological properties of green vegetation, as other solutions to sequester carbon have not yet been proven to be either technologically or economically effective [10,11]. Meanwhile, climate change is a global issue and needs to be addressed through global cooperation among countries to improve energy efficiency, develop and deploy clean technologies, and increase natural GHG absorption. In this context, the processes in and around land use, land use change, and forestry (LULUCF) are becoming crucially important. The LULUCF sector includes GHG emission and its removal from forests, arable or producing land, grasslands and pastures, wetlands, built-up areas, and other land plots. Emissions and removals of GHGs are accounted using internationally accepted approaches [12–14]. However, in order to actively increase carbon absorption, it is necessary to know and manage the processes involved in the development of land surface layers and land use. Cognitive processes and management decisions will be hampered by a lack of access to scientifically based tools for modeling land use and hence GHG emissions.

Nowadays, many land use change modeling tools exist, differing in their methodological implementation [15,16]. They may cover universal or very specific application fields, with the focus on local case studies or continental exercises. There are several concepts of land cover and use modeling [17]—economic models, system dynamics approaches, cellular automata, and agent-based models. Spatial economic or econometric models deliver generalized predictions of states of phenomenon by balancing various inter-related input factors determining their development. System dynamics or causality-driven models assume an empirical modeling of land cover or land use changes. This involves (i) an assessment of past changes first, (ii) a determination of relationships between land changes and factors driving such changes, (iii) an evaluation of change potential, and (iv) an allocation of land to the new land cover or land use types [18]. Cellular automata usually operate in a raster domain, representing the landscape as an n-dimensional grid of cells. Each cell may acquire a finite number of states, which may change over time following some set of rules and depending on the state of neighboring cells. Models are iterated over time, delivering land cover or land use status within the cell at specific times [19,20]. Agent-based models are aimed at modeling the behavior of autonomous individuals (agents) who may perceive their environment and interact with individuals [21]. Even though there are numerous potential solutions for land use change modeling, their applicability is heavily restricted by various legal, technological, and organizational aspects. The land use change modeling depends on the specific requirements of GHG emission accounting, the availability and specifics of input data, modeling tools, and experiences, especially when considering specific countrywide exercises.

There are many factors influencing GHG emissions and absorptions in the LULUCF sector, potentially resulting in uncertainties in both GHG accounting and projections [22–26]. Simultaneously, availability, or often the lack of input data for land use change analysis, makes the task more challenging [27]. Even though there are international standards to account for GHGs, there are always some specialties present in the operational approaches of each country. Lithuania, following its international climate change mitigation commitments, has developed an original LULUCF monitoring system, which is used for GHG reporting. This system predetermines the approaches of land use development projections. The core data source for GHG accounting from the LULUCF sector in the country is the National Forest Inventory (NFI), which is implemented by the State Forest Service [28,29]. Originally developed to provide statistical information on forest resources for strategic forestry planning at a country level, the Lithuanian NFI has recently been expanded to collect countrywide data on land uses and land use changes. The land uses are monitored in a systematic network of observation points through the whole country, while forest attributes are surveyed at points in the forest. There are operational solutions introduced in Lithuania to model the development of forest resources and forestry, ranging from forest stand-level simulators to systems manipulating aggregated countrywide data [30–32]. The State Forest Service uses the European Forestry Dynamics Model (EFDM), developed as a harmonized forestry modeling tool for all European countries, based on NFI data. The EFDM has been used to calculate the forest reference level (FRL) for Lithuania following the European Union LULUCF regulation for 2021–2030 [13]. The EFDM is a matrix-based model of a Markov chain type representing change by transition of areas (in this case, the NFI sample plots) between different fixed states of the forest [33]. This matches well with the system dynamics or causality-driven models introduced above. The reference levels for land uses other than forest are based on historical data, thus, one may assume that no sophisticated modeling solution is needed. Nevertheless, successful land use management provides challenges for modern decision-support tools which are based on land use development scenarios. To our knowledge, the solution that has been widely used to make GHG projections in the LULUCF sector in Lithuania has been the land use, land use change and forestry emission accounting tool, LULUCFeat [34]. LULUCFeat delivers GHG predictions based on aggregated LULUCF data and past trends, using information on driving factors and expert knowledge. Methodologically, this fits the economic models mentioned above.

However, the solution is too focused on delivering certain GHG reports and underfitting expectations for a versatile land use change modeling system, based on all NFI data and compatible modeling principles.

Thus, the aim of the study introduced in this paper is to test the methodological principles for land use development scenario modeling for use in processes of GHG accounting and management. First, we ask what is the performance of the Markov chain analyses methodological approach in modeling land use development using standard GIS software? To conduct the modeling exercise, we use inputs available from already running in Lithuania inventory projects and freely available geographic databases. Then, we test the capacity of the LULUCF sector in Lithuania to accumulate carbon during the next decade, starting in 2020. For that, we project the development of major land use types in Lithuania until 2030 using several land use management scenarios and estimate potential contributions of different land uses on carbon emission/absorption. We hypothesize that the carbon accumulation in the LULUCF sector in Lithuania during the next decade should increase. Finally, we end with a discussion and proposals for both methodological enhancements of modeling solutions and land use management policies.

2. Materials and Methods

2.1. Study Area

The study was conducted in Lithuania, located in Central Europe (Figure 1) and having historically strong links with Eastern Europe. Land use development in Lithuania in recent decades strongly depended on the radical societal transformations after Lithuania broke away from the Soviet Union in 1990 and later joined the European Union in 2004 [35]. The area of three land uses important in GHG accounting and management (forest, producing land and grassland) was rather similar (around 28–30%) in 1971. Then, the proportions of forest, wetland, built-up areas, and other land use types changed relatively steadily since 1971, while the trends of producing land and grassland development changed their trajectories around 1990 and again about 2005 (Figure 2). The proportions of forest land and producing land in 2015 were, respectively, 34% and 33%. The proportion of grassland was reduced to 23%, and the proportions of both wetland and built-up land were 5%. It should be noted that the total area of Lithuania is 65,200 km^2.

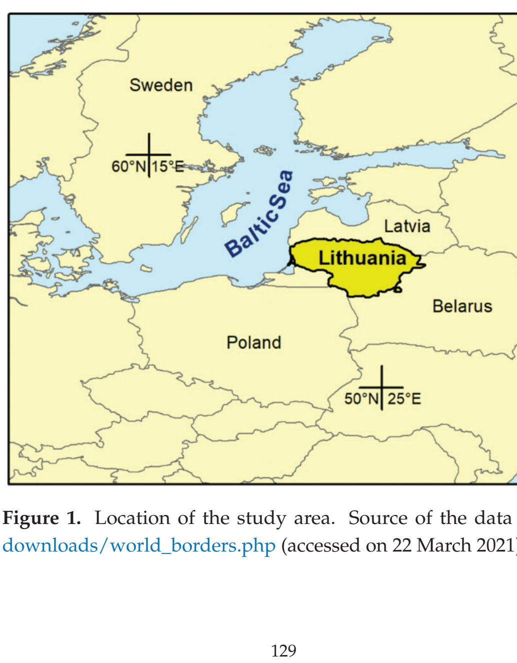

Figure 1. Location of the study area. Source of the data used: https://thematicmapping.org/downloads/world_borders.php (accessed on 22 March 2021).

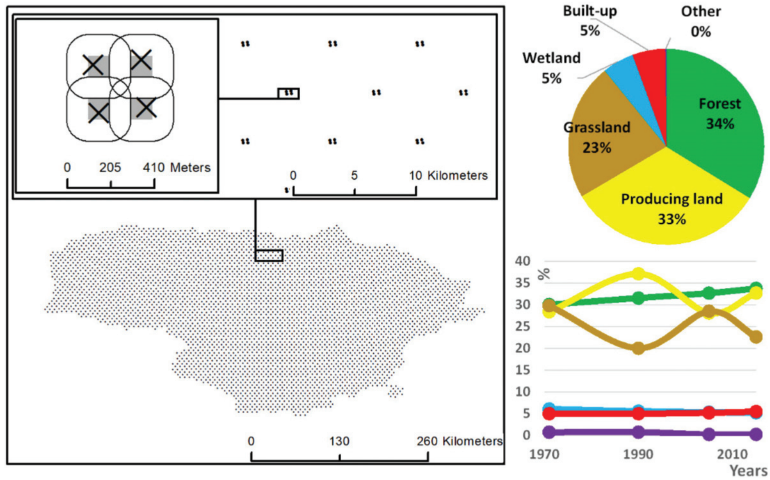

Figure 2. Specification of the study area: (**left**) associative illustration of the distribution of sample plots at different scales, with gray squares referring to the 100 × 100 m cells associated with Lithuanian National Forest Inventory (NFI) sample plots with 100 buffers used to extract driver variables for land use change modeling; (**right**) proportions of major land use types in Lithuania in 2015 and changes in proportions since 1971. Source of the data used: Lithuanian National Forest Inventory.

2.2. Input Data

Two types of input data were used in the study: (i) data describing the land uses in Lithuania and (ii) data describing the factors influencing the land use changes. Land use information was available from the Lithuanian NFI [29,36]. Land use types and subtypes have been identified annually on a network of 16,349 systematically distributed sampling points (Figure 2) since 1971 using the nomenclature of GHG inventories [37]. Usually, three levels of identification are used; however, we used only two levels in our study, i.e., Level 1 with 6 land use types (forest land, producing land, grassland and pastures, wetland, built-up areas, and other land) and Level 2 with 25 subtypes specifying the types in more detail (Appendix A, Table A1 provides a full list of land use subtypes). To conduct the modeling and to integrate the NFI data with other datasets, we created a raster map with a cell size of 100 × 100 m and assured that each NFI plot was associated with a unique cell. Only cells with an NFI plot were used for the study. Free data available from the spatial information portal of Lithuania (www.geoportal.lt, accessed on 22 March 2021) were used to describe the factors influencing the land use changes. The following geographic datasets were used: GRPK (spatial dataset of (geo) reference base cadaster), GDR50LT (georeferenced spatial dataset for the territory of the Republic of Lithuania at the scale of 1:50,000), AZ_DRLT (spatial dataset of abandoned land of the territory of the Republic of Lithuania), SŽNS_DR10LT (database of limited land use areas of the Republic of Lithuania at scale 1:10,000), Dirv_DR10LT (spatial dataset of soil of the territory of the Republic of Lithuania at scale 1:10,000), KŽS (land parcel identification system database), the spatial dataset on the farmland, cropland, and crop types from the National Paying Agency under the Ministry of Agriculture and Population, and the 2011 housing census data from Lithuanian official statistics portal (https://osp.stat.gov.lt/documents/10180/1491916/WHOLE.zip, accessed on 22 March 2021). Two approaches were used to specify the explanatory variables: (i) the area of specific features within a 100 m buffer zone around each 100 × 100 m cell associated with the NFI sample plot was estimated, and (ii) the shortest distance from the NFI sample plot center to specific features was estimated. All explanatory variables were stored as raster maps with a cell size of 100 × 100 m. Optimization of the explanatory variables is described in the next subchapter.

2.3. Modeling Land Use Development

Modeling of the land use development was implemented using the TerrSet 18.21 Land Change Modeler [38]; thus, some approaches used were predefined by the functionality of the available tools. Therefore, the modeling started with an analysis of land use changes between two points in time. The potential of land use transitions was then modeled using a set of driver or explanatory variables. A set of maps of suitability for each transition was developed. Based on land use changes in the past, probabilities of land use change in the future were calculated by building a matrix with probabilities of all possible land use changes. Finally, the land use changes were predicted using the historical rates of change and the transition potential models for a specified date in the future.

Our study consisted of two stages. First, we calibrated and validated land use change modeling using input data freely available in Lithuania. We then simulated land use development for the next decade using several land use change scenarios. The methodological framework of our study is summarized in Figure 3.

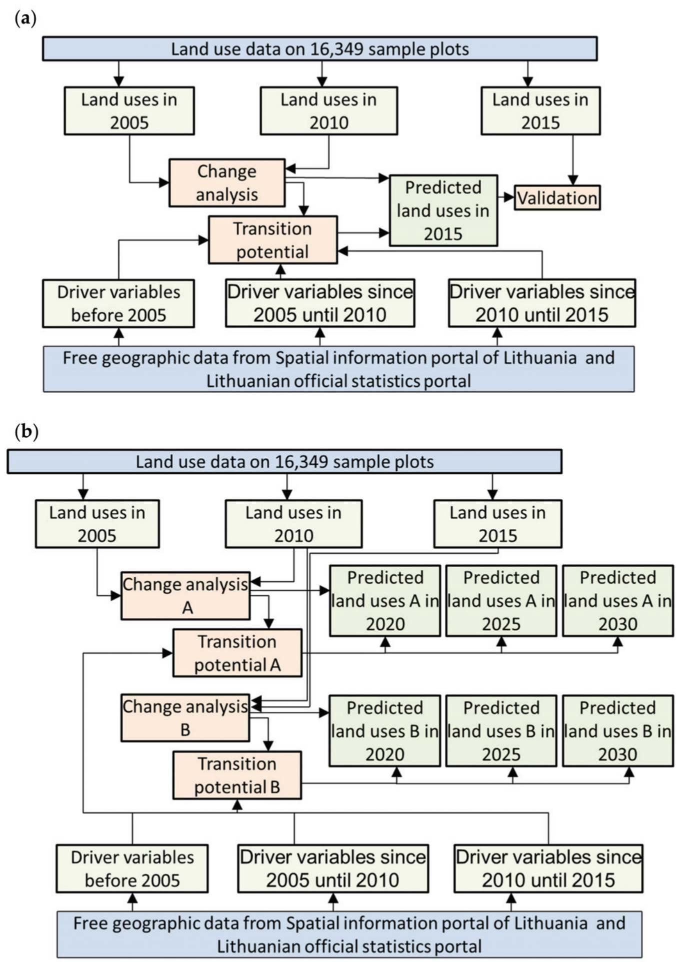

Figure 3. Flowchart summarizing the overall structure of the study: (**a**) calibrating and validating the land use change model, and (**b**) modeling land use development until 2030.

We first analyzed the land use development during the period from 2005 to 2010 to predict land uses in 2015. Transitions were modeled using a multilayer perceptron (MLP) neural network algorithm. All driver variables were tested before using them to build the transition potential models. First, Cramer's V statistic was calculated for each potential explanatory variable—only variables that had a Cramer's V of 0.15 or higher were considered as having potential for modeling. The variable with a higher Cramer's V statistic was considered for modeling among highly intercorrelated variables. Finally, the lists of driver variables were optimized, analyzing the modeling reports delivered by the TerrSet system and iterating the final lists of variables that produced the best MLP performance. All driver variables were considered static. Six strategies were tested to include the driver variables in building the transition potential models, differing by the number and type of driver variables, the date they referred to, and the preprocessing solutions (Table 1).

Table 1. Tested strategies for the inclusion of driver variables in building the transition potential models (+ means that the variables from the respective group were considered or an optimization of variables was applied).

Strategy of Using Driver Variables	Versions of KŽS			AZ_DRLT, SŽNS_DR10LT, Dirv_DR10LT, and Census Data	Land Use Declaration Data	Optimization of Explanatory Variables
	Before 2005	Between 2005 and 2010	After 2010			
1		+		+		
2	+	+		+		
3		+	+	+		
4	+	+	+	+		
5	+	+	+	+	+	
6	+	+	+	+	+	+

Driver variables originating from the KŽS database were grouped according to the date they were created: variables based on data collected (i) before 2005, (ii) between 2005 and 2010, and (iii) after 2010. This was aimed to simulate exercises, where variables changing over time were considered land use development scenario specifications. For example, variables collected after 2010 did not influence the land use change before 2010, but they could be used to specify the future (actual or expected) dynamics of factors influencing land uses. The land use declaration data from the spatial dataset on farmland, cropland, and crop types refer to 2012. The most current versions of other datasets were used. A full list of explanatory variables considered is provided in Appendix A, Table A2. Future land use was predicted using a hard prediction model. The quantity of change in each transition was modeled through a Markov chain analysis.

The second stage of our study included predicting land use development in the future, i.e., acquiring the areas of major land use types for 2020, 2025, and 2030. The sixth strategy using driver variables was applied, i.e., all available explanatory variables were tested before use in the transition potential models. Two options of actual land use change were considered to build the Markov matrix, i.e., (i) the changes from 2005 to 2010 and (ii) from 2010 to 2015. The land use change scenarios were also specified by editing the Markov matrix. The land use development scenarios considered are introduced in Table 2.

Table 2. Description of future scenarios of land use change.

Scenario Title	Main Features for Building the Markov Matrix	
	Period	**Manual Transformations of Transition Probabilities**
Reference (2005–2010) Reference (2010–2015)	2005–2010 2010–2015	-
Producing land to forest (2005–2010)	2005–2010	The probability of transformation of the following land into the forest is doubled: arable land, natural grassland with trees and brush, brush
Producing land to forest (2010–2015)	2010–2015	The probability of transformation of arable land into cultural grassland and pastures is doubled, and the remaining natural grassland with trees and brush is transformed into cultural grassland and pastures
Grassland to forest (2005–2010) Grassland to forest (2010–2015)	2005–2010 2010–2015	All natural grasslands with trees and shrubs are transformed into forest land.
No grassland to producing land (2005–2010) No grassland to producing land (2010–2015)	2005–2010 2010–2015	There is no transformation of grassland/pasture land into producing land, and all other land use changes follow trends during the reference period

To obtain approximate indications of potential contributions of different land uses on carbon emission/absorption, we applied average conversion factors for 2015, as used to prepare the national GHG report from the LULUCF sector [39]; i.e., the following emission values in tons of CO_2 equivalent per ha were used: forest land, 3.93; producing land, 1.43; grassland, 0.51; wetland, 2.64; and built-up land, 1.6; other land, 6.25.

2.4. Validation Approaches

Approaches originating from remote sensing were used to validate the performance of land use prediction. Land use types for the year 2015 were predicted on all NFI sample plots, and the predictions were compared with actual land use types recorded by the Lithuanian NFI. Error matrices were constructed where the true and predicted land use types were cross-tabulated. The validation statistics used to evaluate the prediction were the overall accuracy of prediction and Cohen's kappa:

$$Kappa = \frac{Observed\ accuracy - Expected\ accuracy}{1 - Expected\ accuracy} \tag{1}$$

$$Observed\ accuracy = Overal\ accuracy = \frac{tp}{N} \tag{2}$$

$$Expected\ accuracy = \sum_{i=1}^{k} \frac{nt_i}{N} \times \frac{nc_i}{N}, \tag{3}$$

where tp refers to the number of samples predicted to be positive that are, in fact, positive, k refers to the number of classes, nt_i refers to the number of samples truly in class i, nc_i refers to the number of samples assigned to class i, and N refers to the total number of samples.

The interpretation of Cohen's kappa was as follows: under 0: "poor"; 0–0.2: "slight"; 0.2–0.4: "fair"; 0.4–0.6: "moderate"; 0.6–0.8: "substantial"; 0.8–1.0: "almost perfect" [40].

Land use type–specific prediction performance was evaluated using precision (producer's accuracy), recall (user's accuracy), and the *F*-score (the harmonic mean of recall and precision):

$$Precision = \frac{tp}{tp + fp} \tag{4}$$

where *fp* refers to the number of samples predicted positive that are, in fact, negative;

$$Recall = \frac{tp}{tp + fn} \quad (5)$$

where *fn* refers to the number of samples predicted negative that are, in fact, positive;

$$F\text{-score} = 2 \times \frac{Recal \times Precision}{Recal + Precision} \quad (6)$$

The Z statistic was used to test whether two prediction error matrices were statistically different:

$$Z = \frac{|\hat{\kappa}_1 - \hat{\kappa}_2|}{\sqrt{var(\hat{\kappa}_1) + var(\hat{\kappa}_2)}}, \quad (7)$$

where $\hat{\kappa}_1$ and $\hat{\kappa}_2$ are the Cohen's kappas of compared predictions, and $var(\hat{\kappa}_1)$ and $var(\hat{\kappa}_2)$ refer to the variances of the respective matrices. Compared predictions were treated as statistically differing if Z was more than 1.96 [41].

3. Results

3.1. Calibration and Validation of Land Use Change Models

First, we predicted all land uses in 2015 for all sample points using the input data for 2005–2010 and assuming the Reference scenario. The overall accuracy of prediction was in the range 82–83% (Table 3). The kappa statistic was 0.76–0.77. It seems that the factor inclusion strategy in the calculation of transformation potential had no significant effect on prediction accuracy; the kappa statistics did not differ with statistical significance, with the highest value of the Z statistic being 0.148 (not presented in Table 3). The prediction accuracy statistics of the most encountered land use classes are summarized in Figure 4. The most accurately predicted land cover class is forest land—both the producer's and user's accuracies yielding nearly 99%. The development of built-up areas is also accurately predicted; the F-score is 96%. It is noteworthy that practically in all cases the producer's accuracy (~94.5%) is lower than the user's accuracy (~97.5%), suggesting that other land use classes are more often incorrectly predicted to be transformed into built-up land, rather than vice versa.

The accuracy of predicting the producing land was notably better than that of cultural grassland/pastures, natural grassland, or natural grassland with trees and brush. On average, producing land was predicted with 84–87% accuracies, and the producer's accuracy was higher than the user's accuracy. Cultural grasslands/pastures, natural grasslands, and natural grassland with trees and brush resulted in the lowest prediction accuracies (if considering the most abundant land uses). Only the prediction accuracy for cultural grasslands/pastures reached 50%, and the producer's and user's accuracies did not differ. More in-depth analysis of error matrices confirmed that the abovementioned land uses were mixed with each other during the prediction. Therefore, cultural grasslands/pastures, natural grassland, and natural grassland with trees and brush are combined into one class—grassland. Following this combination, the overall classification accuracy increased by 7–8%, but the increase in kappa was not statistically significant (Table 3). After the merge, grasslands were predicted with 73–80% accuracy, and the producer's accuracy was lower than the user's accuracy. Land with brush was predicted with ~60% accuracy, but the area of this type was relatively small.

The modeling exercise was repeated using the assumptions of Scenario 3: no grassland to producing land (2005–2010). Although the overall prediction accuracy improved by 1–2%, this improvement is not statistically significant. Different scenario conditions had an impact in predicting the grassland development when using detailed grassland subtypes. After combining the grassland subtypes, we achieved very similar producer's and user's accuracies, i.e., differing by no more than 1%.

3.2. Land Use Changes in the Future

Predicted proportions of three major land use types—forest land, producing land, and grassland—are presented in Figure 5. The proportion of forest land is expected to increase regardless of the scenario. It should be noted that scenarios involving active efforts to increase the area of forest land result in larger forest land areas, although never exceeding 37%. Using the land use trends from 2010–2015 to model the transition potential resulted in larger forest land proportions. The area of producing land is expected to increase only if using 2005–2010 land use data to model the transition potential. However, if extrapolating the trends from 2010–2015, the areas of producing land decrease. Manual adjustment of Markov matrices, aimed to specify additional land use policy measures, resulted in even fewer areas of producing land, if compared with the Reference scenarios. If the land use changes during 2010–2015 continue into the future, the proportion of producing land in Lithuania will be reduced to below 30%. The area proportion of grassland is increased if considering the trends during 2010–2015 and, vice versa, decreased if using the 2005–2010 period to model the transition potential. The exception was the scenario with no grassland for producing land, where the grassland decrease stopped by adjusting the Markov matrix. If the land use change trends during 2010–2015 continue in the near future, the proportion of grassland will be projected to increase to 23–28%, depending on the scenario. The lowest grassland proportions were achieved in the scenario of grassland to forest (2005–2010), i.e., following the fast decreasing grassland areas from the half decade, since Lithuania joined the EU and introduced measures for grassland conversion into forest land. It should be noted that the projected trends of producing land development are inversely followed by the trends of grassland proportion.

Table 3. Prediction accuracy of all tested land use types.

Strategy of Using Driver Variables	All Land Use Subtypes		Grasslands Merged into One Class		*Z* Statistics
	Overall Prediction Accuracy	Kappa	Overall Prediction Accuracy	Kappa	
Scenario: Reference					
1	81.9	0.76	87.7	0.83	1.296 *
2	82.1	0.76	88.0	0.84	1.310 *
3	82.2	0.76	88.3	0.84	1.361 *
4	82.1	0.76	88.2	0.84	1.369 *
5	82.8	0.77	88.6	0.84	1.295 *
6	81.9	0.76	88.9	0.86	1.783 *
Scenario: No grassland to producing land (2005–2010)					
1	82.8	0.77	89.5	0.86	0.268/0.467 **
2	82.9	0.77	89.6	0.86	0.228/0.414 **
3	83.0	0.78	89.8	0.86	0.248/0.394 **
4	82.8	0.77	89.5	0.86	0.235/0.349 **
5	83.1	0.78	89.7	0.86	0.112/0.292 **
6	83.1	0.78	89.8	0.86	0.254/−0.022 **

* all classes vs. grassland in the one-class Reference scenario, ** Reference scenario vs. scenario with no grassland for producing land (2005–2010) (in the numerator—all land use subtypes; in the denominator—grasslands merged into one class).

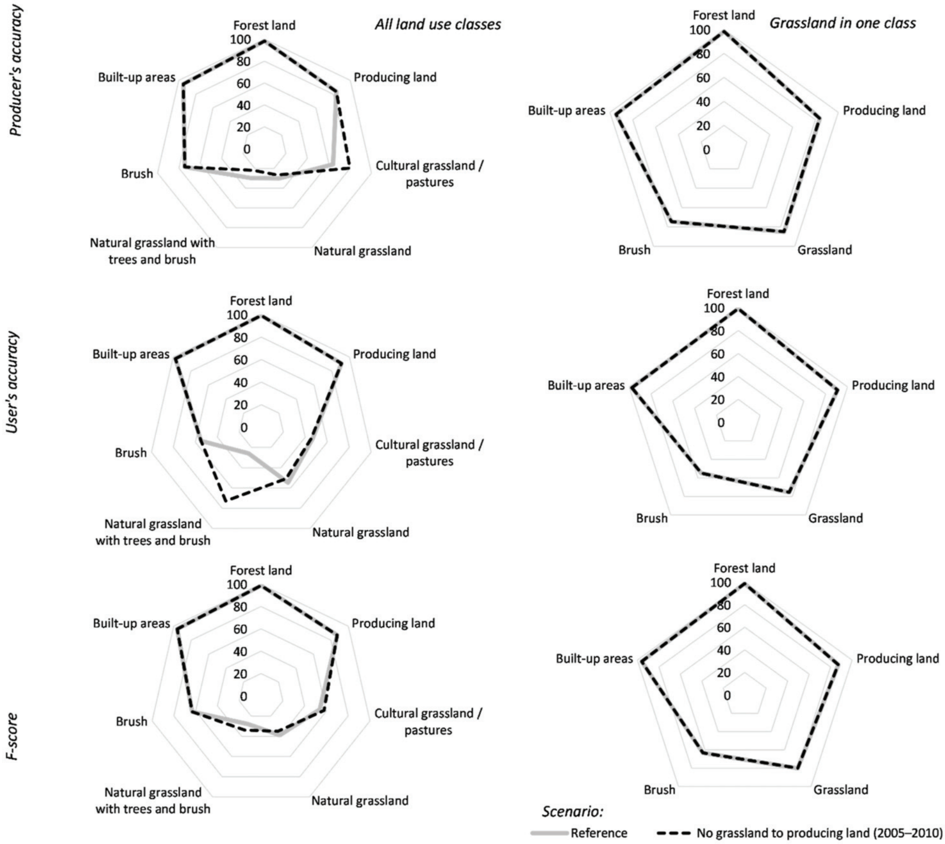

Figure 4. Predicting accuracy of some of the most encountered land uses, achieved using a strategy of driver variable selection based on optimization.

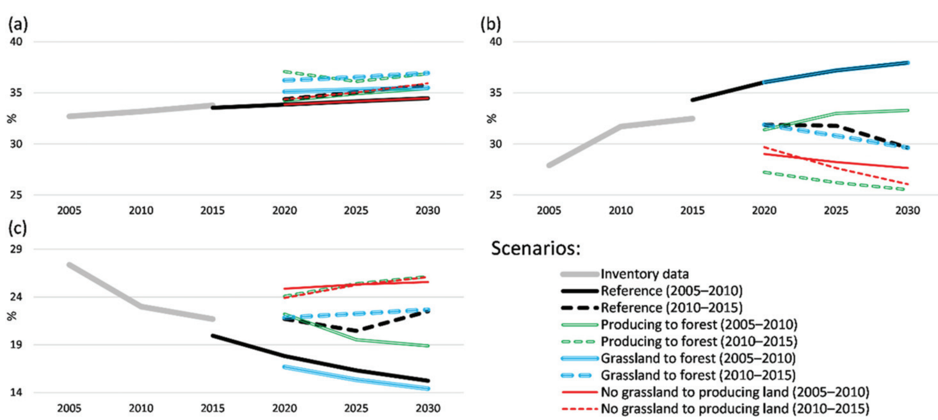

Figure 5. Projected development of selected land uses in Lithuania, depending on land use change scenarios: (**a**) forest land, (**b**) producing land, and (**c**) grassland.

None of the tested scenarios suggested carbon emissions from the LULUCF sector in Lithuania before 2030 (Figure 6). A larger absorption (up to 33%) was projected when considering land use changes that took place from 2010 to 2015 in modeling the transition potential. The largest overall absorption (above 1 ton of CO_2 equivalent from 1 ha) was achieved in the scenario where producing land became forest (2010–2015), i.e., aiming to maximize producing land conversion into forest land.

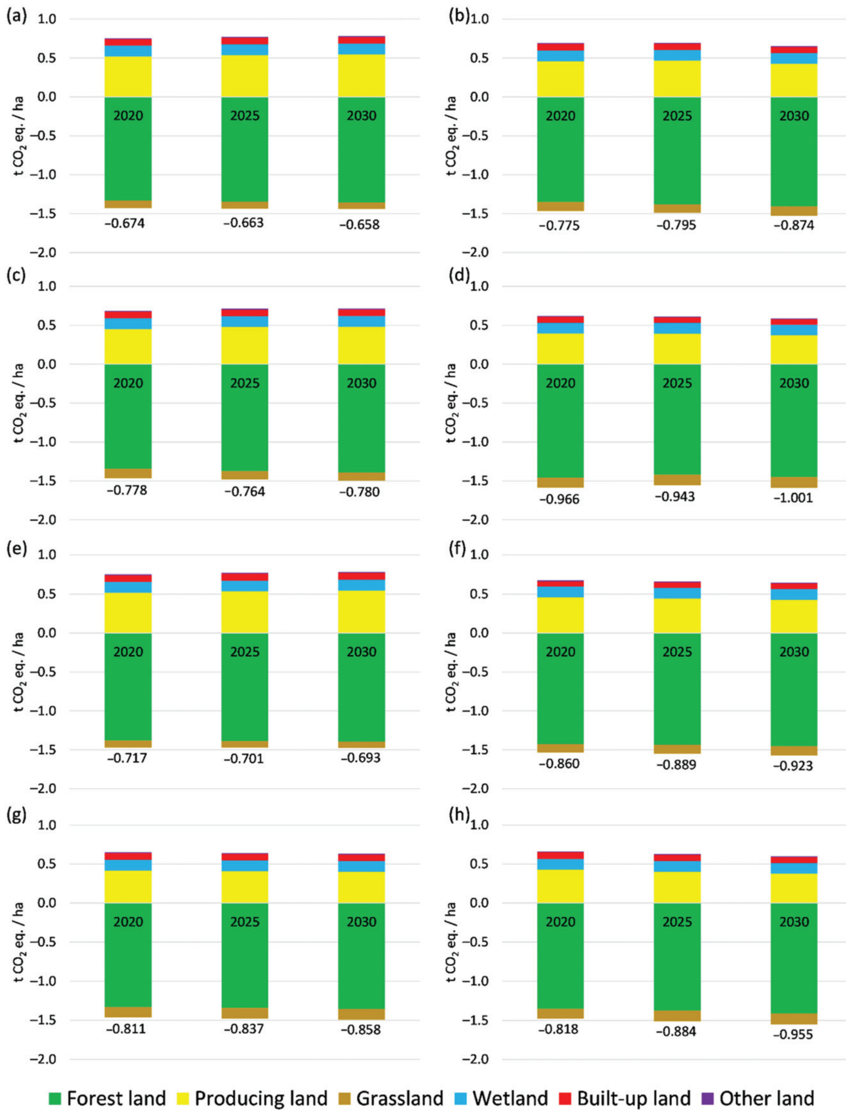

Figure 6. Predicted carbon emission and absorption from the land use, land use change and forestry (LULUCF) sector in Lithuania, depending on scenario: (**a**) Reference (2005–2010), (**b**) Reference (2010–2015), (**c**) producing land to forest (2005–2010), (**d**) producing land to forest (2010–2015), (**e**) grassland to forest (2005–2010), (**f**) grassland to forest (2010–2015), (**g**) no grassland to producing land (2005–2010), and (**h**) no grassland to producing land (2010–2015). The value shown below each bar indicates the total carbon sequestration value. Numeric values can be found in Appendix A, Table A3.

4. Discussion

There are two parts in the discussion that follows. First, we briefly address the choices, findings, and limitations related to the methodological approaches used to predict the land use changes. Second, we use our predictions to discuss potential land use development in Lithuania and the related land use policy implications.

The choice of methodological land use modeling approach was influenced both by the specificity of the general modeling environment and scientific considerations. First, the focus has been on the needs for current land use change modeling in Lithuania. We associate our study with the needs related first to the management of GHG emissions and absorption in the LULUCF sector. Thus, the input data on land use was based on information collected on a network of systematically distributed samples, inheriting differing estimation accuracies for specific land use types. Similar modeling studies usually focus on wall-to-wall land covers or land uses, even though they may be of rather coarse resolution, such as the CORINE database [27]. On the other hand, pointwise land use estimates may make the availability of information driver variables easier, as we do not necessarily need to map wall-to-wall all the factors influencing land use development. Moreover, many driver variables used in the current study are extracted using distance-based, focal, or zonal GIS analysis. Our approach is to use only publicly available information on driver variables, usually downloadable from the spatial information portal of Lithuania (www.geoportal.lt) or freely available from authorized institutions based on license agreements for research and education use. Unfortunately, we could not acquire data on land ownership, which use is commercialized using legal regulations. Finally, our methodological approach had to be compatible with that used by Lithuanian authorities to implement their international commitments, including the European Union land use, land use change, and forestry regulation for 2021–2030 [13], that is, we choose a modeling engine that is compatible with the EFDM, which has been used to calculate the forest reference level for Lithuania and already used to facilitate forest policy building processes. Last but not least, the exercise was implemented using standard GIS software packages, including both data engineering and modeling, i.e., not requiring extra efforts for software development.

The prediction of land cover or land use development in general, and the use of models of the Markov chain type in particular, has always been a very challenging exercise. The most difficult task is to evaluate the transition potential from one land use type into all possible other types. Numerous methodological approaches are reported, such as the weight of evidence [42], empirical probabilities [43], logistic regression [44], and neural network modeling [38,45]. Usually, the results achieved using different solutions are rather different, since studies address very different land use change tasks. Nevertheless, priorities are given to the use of the MLP algorithm, which is a type of neural network [18]. This was also used in our study. Two other methods implemented in TerrSet LCM, a similarity weighted instance-based machine learning algorithm and logistic regression, were rejected in the initial stages of our study, mainly due to the ability to model only one transition at a time and because additional complexity in the modeling exercise did not increase prediction accuracy.

The best prediction accuracies were achieved for land use types that followed linear development trends in recent decades, i.e., forest and built-up lands. Forest land change trends were most stable not only during the modeled period but also throughout the entire accounting period. Afforestation/deforestation is a relatively slow process in Lithuania [46], strictly regulated from a legal point of view, and therefore potentially the easiest to predict. Similarly, the development of built-up areas has also been steadily increasing since 1970. The areas of producing land were increasing in Lithuania since the country joined the EU, usually at the expense of grassland. Thus, the prediction of producing land and grassland changes is very important in supporting land use policies, especially for GHG management, because producing land is associated with carbon emissions, whereas grassland, in contrast, contributes to the carbon accumulation on average [47]. Usually, the misclassifications of producing land as grassland and vice versa were the main types of prediction errors, e.g., ~16% of producing land points were wrongly predicted as grasslands and ~12% of grassland points were wrongly predicted as producing land. Identification of grassland management intensity or differentiating between, e.g., cultural and natural grassland, has always been a challenging task [48]. Using nomenclature for grassland subtypes that is too detailed has resulted in lower prediction accuracies because the grassland types are mixed with each other. Land use type in the Lithuanian inventory system refers to the center point of the sample plot, so the presence of single trees or brush may also be neglected during the inventory, unless the land has not yet been converted into forest land. The increase of forest land is usually very strictly controlled during the inventory, which has always been first focused on evaluating forest resources and involves precise measurements of individual trees on 500 m^2 circular plots [36]. Thus, we continued without specific grassland subtypes. No significant differences were found among the results obtained using different six-factor inclusion strategies for modeling transformation potentials. We explain this by the performance of the MLP, which is a type of machine learning algorithm. However, the number of input driver factors is limited in TerrSet LCM. Therefore, it is suggested that, in the future, the maximum amount of supporting information is collected and used in modeling the selected driver factors that are most strongly related to the land use transformations.

All scenarios tested suggested that the LULUCF sector in Lithuania will accumulate carbon, basically due to carbon accumulation in the forest land. Thus, a further increase of forest land area is extremely important to further contribute to GHG absorption. Nevertheless, none of the scenarios resulted in a forest land area percentage in the country exceeding 37% in 2030. According to official forestry statistics, forest land covered 33.7% of the country's area in 2019 [49]. Our prediction introduces some questions for official forest and land use policies in the country. The political objective is set to increase the forest land area in Lithuania by year 2030 to 23,000 km^2, i.e., 35% of the country's area [50]. Increasing the forest land area proportion in Lithuania is also among the key objectives of national forest policy, primarily associated with the management of GHG emission/absorption [51]. Abandoned or unsuitable agriculture lands are usually identified as afforestation targets in regulations for afforestation and reforestation [52]. In parallel, deforestation is strictly controlled and legally possible only upon the compensation of expenses for establishing new forest land [53]. Therefore, our simulations confirmed that the political afforestation targets can be achieved by 2030. There are no scenarios that suggested forest land reduction, yielding steadily increasing GHG absorption potential. Even though the GHG accumulation in forest land is increased most by introducing active measures to facilitate producing land or grassland transformation into forest land, the first tested option (producing land to forest scenario) most improves the GHG balance from the LULUCF sector.

Assuming that there are limited possibilities to further increase the areas of forest land or reduce built-up areas and wetlands, the key factor to improve the GHG balance in the LULUCF sector will be the proportion of producing land and grassland. If land use management as it was in the period between 2005 and 2010 continues without additional measures to support specific land use transformation types (Reference 2005–2010 scenario), the GHG emissions from agricultural land could increase over the next decade from 2020 by ~9.5%. However, if continuing land use management policies as they were after 2010 (Reference 2010–2015 scenario), GHG emissions could decrease by 20–35% compared with the Reference 2005–2010 scenario, and by 2030 the emissions from agricultural land could be reduced by 11%. Therefore, we can assume that different suggested development trends are affected by changes in Lithuanian land management. Historically, several periods have shaped Lithuanian land management in the last three decades. The largest impact on the use intensity of agricultural lands could be associated with the agrarian reform in the country, which started in 1991. This reform resulted in fully changed formats of agriculture, land management, and land use relationships, and production capacities of agricultural subjects. The second group of impacts is associated with Lithuania joining the European Union in 2004 and the availability of EU and national budget resources to support agriculture and rural development. The factors influencing land use development are usually interdependent, and the outcomes of their inter-relationships during specific periods of socioeconomic development are shaped mainly by political and social factors, with natural conditions playing only a secondary role. Bearing in mind the time periods used to build the land use change models in our study, 2005–2010 could have been influenced by agriculture restructuring (which started in 1991–1992), and the next period is likely associated with the impacts of joining the EU and the state support for agriculture and rural development.

Additional measures to support specific land use transformation types were introduced in the models by manual adjustment of the Markov matrices. Three types of such measures are discussed. First, forcing the transformation of producing land into forest was associated primarily with the strategic forest policy objective to increase the proportion of forest land area, coupled with current land use management efforts to sustain grassland areas or at least to prevent their transformation back to producing land. The second type of measure (grassland to forest) was aimed to increase the forest land area on current grassland. It matches the first scenario, however, with no conditions regarding the efforts to prevent transformations from producing land into grassland. The third type of measure (no grassland to producing land) was associated with additional efforts to prevent grassland transformation into producing land only, i.e., leaving out the extra efforts to increase forest land area. Therefore, if a land use management policy generally follows that in effect from 2005 to 2010, additional measures to support specific land use transformation types will not result in reducing GHG emissions, either from agricultural land or the entire LULUCF sector in the decade starting at 2020. Conversely, GHG emissions from agricultural land are predicted to be reduced in the coming decade if the land use management policy used from 2010 to 2015 is followed. Introducing extra measures would support the reduction of GHG emissions from agricultural land. Especially important in this context is the reduction of producing land by its transformation into forest land (producing land to forest) or preventing the transformation of grassland into producing land (no grassland to producing land). The introduction of such measures may reduce GHG emissions in the next decade by ~16 and 28%, respectively.

Summarizing, in order to improve the GHG balance in the LULUCF sector in Lithuania over the next decade starting at 2020, the focus in Lithuania should be to increase forest and grassland areas. This objective is supported by national strategic political documents, especially those aimed at the effective use of EU support [54–56]. The key contributor to the total CO_2 balance in the LULUCF sector will remain the total forest land area and the potential to increase it in the future. Thus, the EU contribution should be targeted to support the establishment of new forests, assuming that backward processes remain under strict legal restraint. The common agricultural policy (CAP) of the EU should further focus on green direct payment, especially maintaining permanent grassland, which not only supports carbon sequestration but also contributes to the protection of biodiversity (Regulation (EU) No. 1307/2013). In parallel, Lithuania should continue to maintain its permanent grassland [55].

5. Conclusions

The prediction accuracy of land use types directly related to GHG accounting and emission/absorption management in the LULUCF sector in Lithuania was above 80% over a five-year period into the future. Land use types whose abundance changed relatively linearly during the last three decades—forest and built-up lands—were predicted with accuracies of 96% and above. The most challenging was the prediction of land use types on agricultural land, i.e., the separation between producing land and grassland. These results were obtained using a compatible methodological approach based on a Markov chain-type model as used by Lithuanian authorities to estimate forest reference levels for the country following the European Union land use, land use change, and forestry regulation for 2021–2030. It should be emphasized that driver variables affecting land use transformation over time were estimated from information freely available from GIS databases, as the modeling exercise was implemented using standard GIS software.

All scenarios tested suggested that the LULUCF sector in Lithuania would accumulate carbon during the next decade, starting in 2020. The main land use type contributing to the most carbon absorption will remain forest land. Even though the proportion of forest land area in Lithuania is predicted to increase, we did not manage to simulate forest land proportions exceeding 37% of the country's area by either applying land use management approaches as they were applied since 2005 or by introducing additional measures to support forest land expansion. The key factors to improve the GHG balance from the LULUCF sector in the near future, assuming a stable development of forest land and strict deforestation control, are keeping the proportion of producing land and grassland and afforestation of abandoned and uncultivated agricultural lands.

To facilitate CO_2 emission/absorption management in the LULUCF sector together with increasing socioeconomic and environmental benefits of Lithuanian rural landscapes, more sophisticated tools to support the monitoring, analysis, and modeling of land-related mitigation activities are needed. Lithuania has developed an original land use monitoring system that is used for GHG reporting, which, up to some level, predetermines land use development projections. However, even though the system is sufficient to fulfil the country's international climate change mitigation commitments, it encompasses a number of limitations in both substantiating the methodology and the way it is operationally implemented. Further research is needed to improve the methodological framework for integrated land management, which can make use of the digital technologies for inventory and decision support to serve the needs of managers and policy makers with a specific focus on GHG management. More specifically, wall-to-wall mapped land use and land use changes would provide better inputs for land use development scenario modeling using the methodological approach tested in this study. The development of spatially explicit land use change scenario modeling and analysis tools could focus on the use of cellular automata and agent-based modeling approaches.

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Appendix A

Table A1. List of land use subtypes.

Land Use Subtype	Area Proportion in 2015 *
Forest land	33.78
Arable (producing) land	32.49
Cultural meadows and pastures	11.44
Natural grassland	5.16
Natural grassland covered by trees and brush	5.06
Cities, settlements and homesteads	3.84
Natural lakes and rivers	3.02
Roads and railways	1.35
Brush	0.95
Land reclamation ditches	0.87
Wetlands covered by trees and brush	0.64
Wetlands	0.34
Peat bogs	0.34
Orchards	0.15
Other built-up land	0.15
Routes and electricity lines	0.10
Queries	0.10
Berry fields	0.08
Other other land use	0.07
Other meadows and pastures	0.02
Other waters and wetlands	0.02
Short rotation plantations, willow plantations	0.02
Other producing land	0.02
Stony land	0.01

* based on the validation data set.

Table A2. List of explanatory variables tested to predict the land use transition potential.

Description of the Variable	Source Database
Distance based variables	
Distance to the nearest agricultural block in KŽS. If the distance equals 0, then the plot is located in agricultural block	KŽS
Distance to the nearest built-up block in KŽS. If the distance equals 0, then the plot is located in built-up block	
Distance to the nearest miscellaneous block in KŽS (basically, forest). If the distance equals 0, then the plot is located in miscellaneous block	
Distance to the nearest road block in KŽS. If the distance equals 0, then the plot is located on the road	
Distance to the nearest block around linear hydrographic object in KŽS. If the distance equals 0, then the plot is located on the linear hydrographic object	
Distance to the nearest block around areal hydrographic object in KŽS. If the distance equals 0, then the plot is located on areal hydrographic object	
Area proportion-based variables	
Proportion of agricultural land in the zone around the NFI sample plot	
Proportion of built-up land in the zone around the NFI sample plot	KŽS
Proportion of miscellaneous land (basically, forest) in the zone around the NFI sample plot	
Proportion of land associated with the road blocks in the zone around the NFI sample plot	
Proportion of land associated with the blocks around linear hydrographic object in KŽS in the zone around the NFI sample plot	
Proportion of land associated with areal hydrographic object in KŽS in the zone around the NFI sample plot	
Proportion of land associated with the miscellaneous blocks with dominance of land not used for agriculture in KŽS in the zone around the NFI sample plot (for the period after 2010 only)	
Proportion of protected areas in the zone around the NFI sample plot	SŽNS_DR10LT
Proportion of nature heritage areas in the zone around the NFI sample plot	
Proportion of protective zones in the zone around the NFI sample plot	
Proportion of abandoned agricultural land in the zone around the NFI sample plot	AZ_DRLT
Variables available from land declaration data	
Proportion of producing land in the zone around the NFI sample plot	Spatial data set on the farmland, cropland and crop types
Proportion of berry-field land in the zone around the NFI sample plot	
Proportion of orchard land in the zone around the NFI sample plot	
Proportion of other producing land in the zone around the NFI sample plot	
Proportion of forest land in the zone around the NFI sample plot	
Proportion of pastures and meadows in the zone around the NFI sample plot	
Proportion of natural grassland in the zone around the NFI sample plot	
Proportion of other pastures and meadows in the zone around the NFI sample plot	
Proportion of waters and wetlands in the zone around the NFI sample plot	
Other variables	
Average soil productivity grade in the zone around the NFI sample plot	Dirv_DR10LT
Population density in 1 km^2 cell, the NFI sample plot belongs to	Population and housing census 2011

Table A3. Predicted carbon emission and absorption from the LULUCF sector in Lithuania, depending on scenario (numeric values used to build Figure 6, in t CO_2 eq./ha).

Land Use Type	Prediction Years					
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
	Reference (2005–2010)			Reference (2010–2015)		
Forest land	−1.331	−1.343	−1.355	−1.351	−1.378	−1.406
Producing land	0.519	0.535	0.546	0.460	0.468	0.428
Grassland	−0.098	−0.090	−0.085	−0.117	−0.112	−0.123
Wetland	0.139	0.139	0.139	0.138	0.134	0.138
Built-up land	0.084	0.084	0.084	0.083	0.080	0.077
Other land	0.013	0.013	0.013	0.011	0.011	0.011
GHG balance in LULUCF sector	−0.674	−0.662	−0.658	−0.775	−0.795	−0.874
GHG balance in agricultural land	0.421	0.445	0.461	0.343	0.357	0.305
	Producing land to forest (2005–2010)			Producing land to forest (2010–2015)		
Forest land	−1.345	−1.372	−1.392	−1.458	−1.419	−1.449
Producing land	0.451	0.479	0.480	0.393	0.393	0.369
Grassland	−0.120	−0.107	−0.103	−0.128	−0.136	−0.140
Wetland	0.139	0.139	0.139	0.138	0.138	0.138
Built-up land	0.084	0.084	0.084	0.078	0.070	0.071
Other land	0.013	0.013	0.013	0.011	0.011	0.011
GHG balance in LULUCF sector	−0.778	−0.764	−0.780	−0.966	−0.943	−1.001
GHG balance in agricultural land	0.331	0.372	0.377	0.265	0.257	0.228
	Grassland to forest (2005–2010)			Grassland to forest (2010–2015)		
Forest land	−1.380	−1.388	−1.395	−1.424	−1.436	−1.452
Producing land	0.519	0.535	0.546	0.460	0.444	0.428
Grassland	−0.091	−0.084	−0.080	−0.112	−0.116	−0.119
Wetland	0.139	0.139	0.139	0.138	0.138	0.138
Built-up land	0.084	0.084	0.084	0.067	0.069	0.071
Other land	0.013	0.013	0.013	0.011	0.011	0.011
GHG balance in LULUCF sector	−0.717	−0.701	−0.693	−0.860	−0.889	−0.923
GHG balance in agricultural land	0.427	0.451	0.466	0.348	0.329	0.309
	No grassland to producing land (2005–2010)			No grassland to producing land (2010–2015)		
Forest land	−1.331	−1.343	−1.355	−1.351	−1.377	−1.412
Producing land	0.418	0.407	0.399	0.428	0.399	0.376
Grassland	−0.134	−0.136	−0.137	−0.128	−0.136	−0.141
Wetland	0.139	0.139	0.139	0.138	0.138	0.134
Built-up land	0.084	0.084	0.084	0.083	0.080	0.077
Other land	0.013	0.013	0.013	0.011	0.011	0.011
GHG balance in LULUCF sector	−0.811	−0.837	−0.858	−0.818	−0.884	−0.955
GHG balance in agricultural land	0.285	0.271	0.261	0.300	0.263	0.235

References

1. IPCC. Summary for Policymakers. In *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Core Writing Team, Pachauri, R.K., Meyer, L.A., Eds.; IPCC: Geneva, Switzerland, 2014; 151p.
2. Deemer, B.R.; Harrison, J.A.; Li, S.; Beaulieu, J.J.; DelSontro, T.; Barros, N.; Bezerra-Neto, J.F.; Powers, S.M.; Dos Santos, M.A.; Vonk, J.A. Greenhouse Gas Emissions from Reservoir Water Surfaces: A New Global Synthesis. *Bioscience* **2016**, *66*, 949–964. [CrossRef] [PubMed]
3. Frank, D.; Esper, J.; Raible, C.C.; Büntgen, U.; Trouet, V.; Stocker, B.; Joos, F. Ensemble reconstruction constraints on the global carbon cycle sensitivity to climate. *Nature* **2010**, *463*, 527–530. [CrossRef]
4. Fleurbaey, M.; Edenhofer, O.; Pichs-Madruga, Y.; Sokona, E.; Farahani, S.; Kadner, P.E.K.; Seyboth, A.; Adler, I.; Baum, S.; Brunner, T.Z.J.C.M.; et al. (Eds.) Sustainable Development and Equity. In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014; pp. 283–350.
5. Holland, E.A.; Braswell, B.H.; Lamarque, J.F.; Townsend, A.; Sulzman, J.; Mtiller, J.F.; Dentener, F.; Brasseur, G.; Levy, H.; Penner, J.E.; et al. Variations in the predicted spatial distribution of atmospheric nitrogen deposition and their impact on carbon uptake by terrestrial ecosystems. *J. Geophys. Res.* **1997**, *102*, 15849–15866. [CrossRef]
6. Houghton, J.T.; Ding, Y.; Griggs, D.J.; Noguer, M.; van der Linden, P.J.; Dai, X.; Maskell, K.; Johnson, C.A. (Eds.) *Climate Change 2001: The Scientific Basis*; Cambridge University Press: Cambridge, UK, 2001.
7. Friedlingstein, P.; Cox, P.; Betts, R.; Bopp, L.; Von Bloh, W.; Brovkin, V.; Cadule, P.; Doney, S.; Eby, M.; Fung, I.; et al. Climate–Carbon Cycle Feedback Analysis: Results from the C4MIP Model Intercomparison. *J. Clim.* **2006**, *19*, 3337–3353. [CrossRef]
8. Raupach, M.R.; Marland, G.; Ciais, P.; Le Quéré, C.; Canadell, J.G.; Klepper, G.; Field, C.B. Global and regional drivers of accelerating CO_2 emissions. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 10288–10293. [CrossRef] [PubMed]
9. Cox, P.; Jones, C. Climate change—Illuminating the modern dance of climate and CO_2. *Science* **2008**, *321*, 1642–1644. [CrossRef]
10. Leung, D.Y.C.; Caramanna, G.; Maroto-Valer, M.M. An overview of current status of carbon dioxide capture and storage technologies. *Renew. Sustain. Energy Rev.* **2014**, *39*, 426–443. [CrossRef]
11. Cuéllar-Franca, R.M.; Azapagic, A. Carbon capture, storage and utilisation technologies: A critical analysis and comparison of their life cycle environmental impacts. *J. CO_2 Util.* **2019**, *9*, 82–102. [CrossRef]
12. IPCC. *2006 IPCC Guidelines for National Greenhouse Gas Inventories; Prepared by the National Greenhouse Gas Inventories Programme*; Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., Eds.; IGES: Tokyo, Japan, 2006.
13. European Parliament and Council. Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the Inclusion of Greenhouse Gas Emissions and Removals from Land Use, Land Use Change and Forestry in the 2030 Climate and energy Framework, and Amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0001.01.ENG (accessed on 27 December 2020).
14. European Parliament and Council. Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on Binding Annual Greenhouse Gas Emission Reductions by Member States from 2021 to 2030 Contributing to Climate Action to Meet Commitments under the Paris Agreement and amending Regulation (EU) No 525/2013. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32018R0842 (accessed on 27 December 2020).
15. Schaldach, R.; Priess, A. Integrated Models of the Land System: A Review of Modeling Approaches on the Regional to Global Scale. *Living Rev. Landsc. Res.* **2008**, *2*, 1–34. [CrossRef]
16. Wang, S.H.; Huang, S.L.; William, W.; Budd, W.W. Integrated ecosystem model for simulating land use allocation. *Ecol. Model.* **2012**, *227*, 46–55. [CrossRef]
17. Haase, D.; Schwarz, N. Simulation Models on Human—Nature Interactions in Urban Landscapes: A Review Including Spatial Economics, System Dynamics, Cellular Automata and Agent-based Approaches. *Living Rev. Landsc. Res.* **2009**, *3*, 2. [CrossRef]
18. Sangermano, F.; Eastman, J.R.; Zhu, H. Similarity Weighted Instance-based Learning for the Generation of Transition Potentials in Land Use Change Modeling. *Trans. GIS* **2010**, *14*, 569–580. [CrossRef]
19. Batty, M. Geocomputation using cellular automata. In *Geocomputation*; Openshaw, S., Abrahart, R., Eds.; Taylor and Francis: London, UK, 2000; pp. 95–126.
20. De Almeida, C.M.; Batty, M.; Monteiro, A.M.V.; Câmara, G.; Soares-Filho, B.S.; Cerqueira, G.C.; Pennachin, C.L. Stochastic cellular automata modeling of urban land use dynamics: Empirical development and estimation. *Comput. Environ. Urban Syst.* **2003**, *27*, 481–509. [CrossRef]
21. Parker, D.C.; Manson, S.M.; Janssen, M.A.; Hoffmann, M.J.; Deadman, P. Multi-Agent Systems for the Simulation of Land-Use and Land-Cover Change: A Review. *Ann. Assoc. Am. Geogr.* **2003**, *93*, 314–337. [CrossRef]
22. Reisinger, A.; Havlík, P.; Riahi, K.; Van Vliet, O.; Obersteiner, M.; Herrero, M. Implications of alternative metrics for global mitigation costs and greenhouse gas emissions from agriculture. *Clim. Chang.* **2012**. [CrossRef]
23. Oliver, T.H.; Morecroft, M.D. Interactions between climate change and land use change on biodiversity: Attribution problems, risks, and opportunities. *Wiley Interdiscip. Rev. Clim. Chang.* **2014**, *5*, 317–335. [CrossRef]
24. Kuramochi, T.; Höhne, N.; Schaeffer, M.; Cantzler, J.; Hare, B.; Deng, Y.; Sterl, S.; Hagemann, M.; Rocha, M.; Yanguas-Parra, P.A.; et al. Ten key short-term sectoral benchmarks to limit warming to 1.5 °C. *Clim. Policy* **2017**, *18*, 287–305. [CrossRef]

25. Riahi, K.; Kriegler, E.; Johnson, N.; Bertram, C.; Den Elzen, M.; Eom, J.; Schaeffer, M.; Edmonds, J.; Isaac, M.; Krey, V.; et al. Locked into Copenhagen pledges—Implications of shortterm emission targets for the cost and feasibility of long-term climate goals. *Technol. Forecast. Soc. Chang.* **2015**, *90 Pt A*, 8–23. [CrossRef]
26. Rogelj, J.; Popp, A.; Calvin, K.V.; Luderer, G.; Emmerling, J.; Gernaat, D.; Fujimori, S.; Strefler, J. Scenarios towards limiting global mean temperature increase below 1.5 °C. *Nat. Clim. Chang.* **2018**, *8*, 325–332. [CrossRef]
27. Dzieszko, P. Land-cover modelling using CORINE Land Cover data and multi-layer perceptron. *Quaest. Geogr.* **2014**, *33*, 5–22. [CrossRef]
28. Konstantinavičiūtė, I.; Byčenkienė, S.; Kavšinė, A.; Zaikova, I.; Juška, R.; Žiukelytė, I.; Lenkaitis, R.; Kazanavičiūtė, V.; Mačiulskas, M.; Juraitė, T.; et al. *Lithuania's National Inventory Report 2018: Greenhouse Gas Emissions 1990–2016. Ministry of Environment, Environmental Protection Agency*; State Forest Service: Vilnius, Lithuania, 2018; p. 617. Available online: https://am.lrv.lt/uploads/am/documents/files/%C5%A0ESD%20apskaitos%20ir%20kt%20ataskaitos/LT_NIR_FINAL_2018.pdf (accessed on 9 November 2020).
29. Kulbokas, G.; Jurevičienė, V.; Kuliešis, A.; Augustaitis, A.; Petrauskas, E.; Mikalajūnas, M.; Vitas, A.; Mozgeris, G. Fluctuations in gross volume increment estimated by the Lithuanian National Forest Inventory compared with annual variations in single tree increment. *Balt. For.* **2019**, *25*, 105–112. [CrossRef]
30. Barreiro, S.; Schelhaas, M.-J.; Kändler, G.; Antón-Fernández, C.; Colin, A.; Bontemps, J.-D.; Alberdi, I.; Condés, S.; Dumitru, M.; Ferezliev, A.; et al. Overview of methods and tools for evaluating future woody biomass availability in European countries. *Ann. For. Sci.* **2016**, *73*, 823–837. [CrossRef]
31. Orazio, C.; Montoya, R.C.; Régolini, M.; Borges, J.G.; Garcia-Gonzalo, J.; Barreiro, S.; Botequim, B.; Marques, S.; Sedmák, R.; Smreček, R.; et al. Decision Support Tools and Strategies to Simulate Forest Landscape Evolutions Integrating Forest Owner Behaviour: A Review from the Case Studies of the European Project, INTEGRAL. *Sustainability* **2017**, *9*, 599. [CrossRef]
32. Mozgeris, G.; Brukas, V.; Pivoriūnas, N.; Činga, G.; Makrickiene, E.; Byčenkienė, S.; Marozas, V.; Mikalajūnas, M.; Dudoitis, V.; Ulevičius, V.; et al. Spatial pattern of climate change effects on Lithuanian forestry. *Forests* **2019**, *10*, 809. [CrossRef]
33. Packalen, T.; Sallnäs, O.; Sirkiä, S.; Korhonen, K.; Salminen, O.; Vidal, C.; Robert, N.; Colin, A.; Belouard, T.; Schadauer, K.; et al. *The European Forestry Dynamics Model: Concept, Design and Results of First Case Studies*; EUR 27004; Publications Office of the European Union: Luxembourg, 2014. [CrossRef]
34. Konstantinavičiūtė, I.; Miškinis, V.; Galinis, A.; Lekavičius, V.; Tarvydas, D.; Norvaiša, E.; Pažėraitė, A.; Bobinaitė, V.; Gatautis, R.; Alėbaitė, I.; et al. *Nacionalinių Išmetamų į Atmosferą Šiltnamio Efektą Sukeliančių Dujų Kiekio Prognozių Rengimo Metodinių Gairių Parengimas: Galutinė Ataskaita*; Lietuvos Energetikos Institutas: Kaunas, Lithuania, 2016.
35. Jukneliené, D.; Valčiukienė, J.; Atkocevičienė, V. Assessment of regulation of legal relations of territorial planning: A case study in Lithuania. *Land Use Policy* **2017**, *67*, 65–72. [CrossRef]
36. Kuliešis, A.; Kasperavičius, A.; Kulbokas, G. *Lithuania (Book Chapter). National Forest Inventories—Assessment of Wood Availability and Use*; Vidal, C., Alberdi, I., Hernandez, L., Redmond, J., Eds.; Springer International Publishing: Cham, Switzerland, 2016; Chapter 28; pp. 521–547.
37. IPCC. *Good Practice Guidance for Land Use, Land-Use Change and Forestry*; Institute for Global Environmental Strategies: Kanagawa, Japan, 2003.
38. Eastman, J.R. *TerrSet Manual*; Clark University: Worcester, MA, USA, 2015; 394p, Available online: www.clarklabs.org (accessed on 3 January 2021).
39. Lithuania's National Inventory Report 2018. Greenhouse Gas Emissions 1990–2016. Vilnius, Lithuania. 2018. Available online: https://klimatas.gamta.lt/files/LT_NIR_20180415_final.pdf (accessed on 3 January 2021).
40. Landis, J.R.; Koch, G. The measurement of observer agreement for categorical data. *Biometrics* **1977**, *33*, 159–174. [CrossRef] [PubMed]
41. Congalton, R.G.; Green, K. *Assesing the Accuracy of Remotely Sensed Data—Principles and Practices*; CRC Press: Boca Raton, FL, USA, 1999.
42. Soares-Filho, B.S.; Cerqueira, G.C.; Pennachin, C.L. Dinamica—A stochastic cellular automata model designed to simulate the landscape dynamics in an Amazonian colonization frontier. *Ecol. Model.* **2002**, *154*, 217–235. [CrossRef]
43. Pontius, R.G.; Schneider, L.C. Land-cover change model validation by a ROC method. *Agric. Ecosyst. Environ.* **2001**, *85*, 239–248. [CrossRef]
44. Verburg, P.; De Koning, G.; Kok, K.; Veldkamp, A.; Bouma, J. A spatial explicit allocation procedure for modelling the pattern of land use change based upon actual land use. *Ecol. Model.* **1999**, *116*, 45–61. [CrossRef]
45. Pijanowski, B.C.; Brown, D.G.; Shellito, B.A.; Manik, G.A. Using neural networks and GIS to forecast land use changes: A Land Transformation Model. *Comput. Environ. Urban Syst.* **2002**, *26*, 553–575. [CrossRef]
46. Jukneliené, D.; Mozgeris, G. The spatial pattern of forest cover changes in Lithuania during the second half of the twentieth century. *Žemės ūkio Mokslai* **2015**, *22*, 209–215. [CrossRef]
47. Lithuania's National Inventory Report 2021. Greenhouse Gas Emissions 1990–2019. Draft. 2021. Available online: https://am.lrv.lt/uploads/am/documents/files/KLIMATO%20KAITA/%C5%A0ESD%20apskaitos%20ir%20kt%20ataskaitos/NIR_2021_01_15%20FINAL.pdf (accessed on 10 January 2021).
48. Estel, S.; Mader, S.; Levers, C.; Verburg, P.H.; Baumann, M.; Kuemmerle, T. Combining satellite data and agricultural statistics to map grassland management intensity in Europe. *Environ. Res. Lett.* **2018**, *13*, 074020. [CrossRef]

49. Lithuanian Statistical Yearbook of Forestry. Ministry of Environment, State Forest Service. 2019. Available online: http://www.amvmt.lt/index.php/leidiniai/misku-ukio-statistika/2019 (accessed on 14 January 2021).
50. Lietuvos Respublikos Teritorijos Bendrasis Planas. Konkretizuoti Sprendiniai: Teritotinių Elementų Vystymas. Available online: http://www.bendrasisplanas.lt/wp-content/uploads/2020/07/LR-BP-Teritorini%C5%B3-element%C5%B3-vystymas.pdf (accessed on 14 January 2021).
51. Decision No. 569. 2012. Available online: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.425608 (accessed on 22 January 2021).
52. Order No. D1-199. 2008. Available online: https://www.e-tar.lt/portal/lt/legalAct/TAR.E0061030F4E1/asr (accessed on 22 January 2021).
53. Decision No. 1131. 2011. Available online: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.407618?jfwid=-1n2mj1nis (accessed on 22 January 2021).
54. Lietuvos 2007–2013 m. Kaimo Plėtros Programa: Europos Komisija, 2007 m. rugsėjo 19 d. Nr.1698/2005. Available online: https://zum.lrv.lt/uploads/zum/documents/files/LT_versija/Veiklos_sritys/Kaimo_pletra/Lietuvos_kaimo_pletros_2007%E2%80%932013%20m._programa/KPP20072013LT20141222.pdf (accessed on 22 January 2021).
55. Lietuvos 2014–2020 m. Kaimo Plėtros Programa. Europos Komisija, 2015 m. vasario 13 d.Nr. C(2015)842. Available online: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/rdp-lithuanua-fulltext_lt.pdf (accessed on 22 January 2021).
56. European Parliament and Council. Regulation (EU) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 Establishing Rules for Direct Payments to Farmers under Support Schemes within the Framework of the Common Agricultural Policy and Repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009. Available online: http://data.europa.eu/eli/reg/2013/1307/oj (accessed on 14 January 2021).

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Land-Use Planning and the Public: Is There an Optimal Degree of Civic Participation?

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Abstract: Civic participation has an irreplaceable role in the land-use planning process because it contributes a practical perspective to expert knowledge. This article discusses whether there is actually a level of civic participation that can be considered optimal, which would allow experts to effectively obtain information from everyday users of the territory, who have the best practical knowledge of it; experts may also gain sufficient feedback on intended developments, based on knowledge about civic participation from representatives of individual municipalities. The article also proposes measures that can promote an optimal degree of participation in the land-use planning process. The fieldwork was conducted in the form of semi-structured interviews with the mayors of municipalities with a population of up to 2000 inhabitants in selected districts of the Ústí Region (Czech Republic). The results suggest that the optimal degree of civic participation in land-use planning should have a representative extent, so it should not merely be a matter of individuals, but also one of groups of dozens of people, and such groups should encompass a balanced variety of characteristics; an optimal level of civic participation should also provide the maximum number of relevant impulses. Measures that may secure and foster an optimal degree of civic participation in land-use planning include (1) striving to avoid preferring purely voluntary participation; (2) simultaneously utilizing various tools to engage inhabitants; (3) educating inhabitants on a regular basis; and (4) consistently communicating and providing feedback, while also searching for informal means of communication and discussion.

Keywords: participation; engagement; optimal degree; land-use planning; land-use plan

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1. Introduction

Participation is currently regarded as a major element of the planning process, as it seeks answers to questions of public interest—with the public's assistance [1]—so its application helps strengthen and advance democracy [2,3], especially aggregative democracy [4]. Participation leads to collaborative learning [3–5], which facilitates discussions between involved parties [6]. Participation also has a psychological dimension, as it supports people's need to express themselves and be part of something [7]. From a planning approach perspective, participation is the core component of "bottom-up" planning [8].

Effective and sustainable planning can rarely be achieved by expert knowledge alone, and civic participation offers a means of complementing the expert view [9]. At the same time, individual intentions should always be pre-emptively assessed to see whether participation is relevant and beneficial to the given project [10]. Participation has a positive effect on planning overall, though individual particularities will always display certain negatives as well [11]. For this reason, this article seeks to present a comprehensive evaluation of participation with regard to both positive and negative aspects in the land-use planning process, and aims to answer the primary question, contained in the paper's title, regarding whether an optimal degree of civic participation exists and can be defined. If possible, this would effectively enable experts to acquire information from everyday users of the territory, who have the best practical knowledge of it, while also gaining feedback on intended developments.

The aim of the article is to assess whether there is an optimal level of civic participation in the land-use planning process, and if so, to define its form and typical attributes, based on knowledge about civic participation from representatives of individual municipalities. A secondary aim of the paper is to suggest suitable ways of facilitating an optimal degree of participation in the land-use planning process. The research is based on the author's fieldwork, which is supplemented by theoretical findings based on a survey of the relevant literature.

2. Civic Participation and Land-Use Planning

Land-use planning is a necessary instrument for the deliberate management of land and the sustainability of territorial policy [12], and participation currently has a solid tradition and is regarded as one of the core pillars of territorial policy, so much so that the term "communicative planning" is used [13]. Participation of the public is essential for obtaining local knowledge [5], which can be harnessed to improve the planning process [11,14], as it helps predict and identify areas of potential conflict in future land use [15]. If the experts (planners) understand these problems and the overall mode of operation of the given territory, they can plan effectively [16–18]. The issue is influenced by the region's historical experience with participation, which may determine the form of participation in relation to politicians and experts versus citizens and civic movements. Therefore, participation may manifest as conflict in one place and neutral cooperation elsewhere [19].

Land-use planning is a political instrument designed to ensure the sustainable development of a territory, and it is important for the involved parties to communicate and negotiate together. For this reason, the present approach to land-use planning is sometimes termed "participatory land-use planning" (PLUP) [20]. Civic participation may take various forms within the land-use planning process; some examples with regard to direct contact between citizens and experts include hearings, dialogue meetings, and workshops [21], or other types of a visual nature [22]. Participatory tools can be hard or soft [23], where "hard" tools are derived from legislation [24], such as public hearings [25], and "soft" tools have a more informal and supplementary character, such as public surveys or participatory workshops [26].

2.1. Civic Participation: The Strengths and Positives in Land-Use Planning

Participation brings decisions closer to those actors of territorial development [27] who are everyday users of the territory, thus helping to identify the consistency, compatibility, or potential conflict in the territory's use [28]. Civic participation is a means of applying the "know-how" of local inhabitants to the planning process [29], and it facilitates familiarity with the mode of operation and natural conditions of the given area [3], consequently enabling a higher effectiveness in decision-making [2]. Participation may also have a preventative character, as it can avoid potential future protests of citizens against the implementation of the planned intentions [30]. With more relevant parties, including inhabitants, involved in the planning process, better solutions can be found to individual problems [31], leading to greater public satisfaction with the chosen solution [2]. Civic participation also improves the overall effectiveness of planning and citizens' satisfaction with the process [32], making it more legitimate and informed [6].

If the findings obtained from the public are applied to a sufficient extent, the land-use plan and the individual decisions subsequently based off of it may benefit from a higher effectiveness and efficiency [18,33], as planning sourced solely from expert and academic perspectives is often lacking in terms of the effect [32]. Citizens may also provide basic information, and they are one of the cornerstones of a successful transformation into a smart city or village [34]; people with matching intentions and interests may also associate and form groups and coalitions [35], which may bolster local social cohesion. The ever-growing use of online technologies also offers a greater potential for public engagement [36].

2.2. Civic Participation: The Weak Points and Negatives in Land-Use Planning

Participation in land-use planning is generally required by law [23], but this often takes on a mostly pro-forma character [37], and participatory mechanisms are very weakly institutionalized [38]. This explains why, in practice, steps that reinforce participation are rarely made voluntarily, and are instead mandated by legislation [39], which merely illustrates how little importance is accorded to participation by many politicians and experts [40]. Experts generally lack sufficient skills to effectively incorporate the inhabitants' input into their land-use planning, even when they consider it valuable [37,41], yet on the other hand, they do not necessarily always respect or trust these lay opinions and observations, as most citizens do not wield expert knowledge and do not comprehensively understand the process in all its complexity [42]. Nonetheless, it is important for experts to have the ability to communicate [43], because the intentions and perspectives of experts and the public may differ drastically [44]. Another issue is the frequent absence of any methodological framework for participatory planning [45].

Local knowledge has a largely spatial character [3], which does not allow it to be applied elsewhere [46,47], while conversely, there can be no universally valid solution [18]. There is also the danger of participatory bias, in which certain groups promote their own interests [48], seeking individual benefits to the possible detriment of the territory's land-use planning, such as in the case of flood risk [49,50], as a consequence of their preference for rapid returns on investment [40]. All in all, land-use planning offers considerable potential for self-enrichment, which may also be channeled via participation—for example, when changing a property's use class (such as turning agricultural land into a building lot)—and this invites a real risk of corruption. Therefore, planning should incorporate anti-bribery measures [51].

With regard to participation, it is ill-advised to rely solely on voluntary engagement by citizens, as this does not provide comprehensive information about the territory [52]. Voluntary participation usually generates an uneven representation of individual categories of citizens—for example, young inhabitants evince minimal engagement [53]—whereas individual groups (variably classified by age or selection method) may identify different problems and define divergent preferences [52]. Therefore, if a group is not represented during the planning process, its opinions and needs are not reflected in the resulting plan. The non-participation of individual groups can lead to the plan's faulty interaction with the local environment [53], and so it is always important to involve all parties and groups based on various criteria [45], instead of only relying on voluntary, self-induced engagement [48]. In practice, the initiating entity often fails to achieve a desirable level of actual participation [39], as local governments and planners only rely on voluntary participation and do not actively seek information other ways [52].

2.3. Challenges for Civic Participation and Land-Use Planning

Interaction between individual citizens, their communities, and policy-makers is important [3], yet these groups often evince a lack of social cohesion, which limits the community's ability to participate [54]. Despite this, for planners, politicians, and citizens to be able to plan correctly and efficiently, they must have sufficient information about the given territory [12], and such critical information and knowledge can be obtained from the citizens, including inhabitants and owners of property [55]. With regard to participation, it is suitable to designate the relationship between planning and private ownership, which is seen as a potential threat if left unregulated, in the sense of the unproductive and uneconomic use of land [56], and this leads to the necessity of private participation [2].

For citizens to be engaged, they must be intrinsically motivated to become involved in the process [57], and the best way to secure their engagement is to induce in citizens the feeling that they own a given project (such as the municipality's territory via the land-use plan), which will lead to their greater creativity and effort [58]. However, for that to be possible, citizens must be informed about both the land-use planning process itself and their means of involvement [36]. It is important to convince the inhabitants that participation in the land-use planning process is a key instrument for ensuring the sustainable development of the territory [14,37], which may in turn secure good living conditions and satisfy the needs of the territory's inhabitants in the long term [16,40]. Primarily, it would be suitable to cultivate in citizens the sense that participation and policy co-creation is the mark of a "good citizen" [59]. At the same time, the added value of public participation must be considered [60], and there is a need to define the criteria for public participation for the purpose of evaluating the participatory tools used [8].

Local governments should be open to both traditional and new forms and instruments of public engagement [61]. A prominent current topic with regard to participation is the use of information and communication technologies [36], the potential of "Web 2.0" [52], and online instruments to boost citizens' involvement in land-use planning [62], such as public participation GIS (PPGIS), participatory GIS (PGIS), and volunteered geographic information (VGI) [52,63–65]. Online tools have added value in how they facilitate the dissemination of information, public involvement, and the accumulation of local knowledge [60], though one negative is social injustice, as not all groups of the population are able to use these instruments equally well [60]. For example, the use of social networks brings the issue closer to younger inhabitants, whereas paper questionnaires ensure a better spread of individual age groups in the surveys, but do not address the question of the respondents' different levels of education [66].

3. Research Methodology

The spatial scope of the research was limited to municipalities in one of the Higher Territorial Administrative Units of the Czech Republic, namely, the Ústí Region. This territory is further divided into seven districts, which are of administrative and statistical significance. The research took place in only four of these districts, located in the central and eastern parts of the Ústí Region, namely, the districts of Teplice, Ústí nad Labem, Děčín, and Litoměřice. The remaining three districts of Chomutov, Most, and Louny were not taken into account, as a relevant research sample was already assembled using the first four districts mentioned.

Specific municipalities were chosen using the stratified random sampling method [67], with the population size as the primary criterion, with an upper limit (maximum) of 2000 inhabitants and no lower limit (minimum). The selected municipalities were then approached to ascertain whether they have their own land-use plan (Czech municipalities are not obliged to have one); this ensured that the municipalities had experience with the analysed issue of land-use planning. All of the selected municipalities met this condition. As of 31 December 2018, the chosen territory contained a total of 180 municipalities with a population of up to 2000 [68]. Of these, 63 municipalities were approached with a request for an interview, which was then carried out in 24 of them (Figure 1); these constitute the case study. The request for an interview was refused in nine municipalities, mainly due to the busy schedules of local representatives, or for reasons of personal leave or a sense of having an insufficient competency to address the issue. The remaining municipalities (30) did not respond to the email request.

The fieldwork was conducted in the form of personal interviews with the mayors of the municipalities. The Czech Republic features a relatively large number of units of basic local government (municipalities), and so, especially in low-population municipalities, the mayor is often the "only employee", whose position also gives him or her a complex view of the municipality's daily operations and development; mayors also very frequently retain their office for several terms. Interviews were chosen as a research technique for efficient data collection, using a semi-structured format [67,69], based on a set of pre-determined yet open questions. One advantage of this type of interview is that its semi-structured nature limits the subjective influence of the questioner and improves the potential for further analysis [67], while providing opportunities to cover issues that only appeared in the course of the interview [69]. One disadvantage is that the interviews are standardized, which can detract from their authenticity and flexibility [67]. All the interviews were performed by the same person to ensure that they were conducted in the same manner and maintained cohesion. The respondents were promised in advance that their words and the information they provided would be anonymized, and so, after the conclusion of the fieldwork, the individual interviews were code-numbered before being analysed. The mayors were contacted solely by email in early July 2019, and the interviews took place in the period from 24 July to 21 September 2019. In three cases, the deputy mayor replaced the mayor for the interview due to scheduling conflicts or unavailability of the latter. The duration of each interview ranged from 15 to 30 min and averaged 20 min. All the interviews were conducted and analysed in Czech, with excerpts then translated into English for the purpose of this article. A summary of the respondents is given in Table 1.

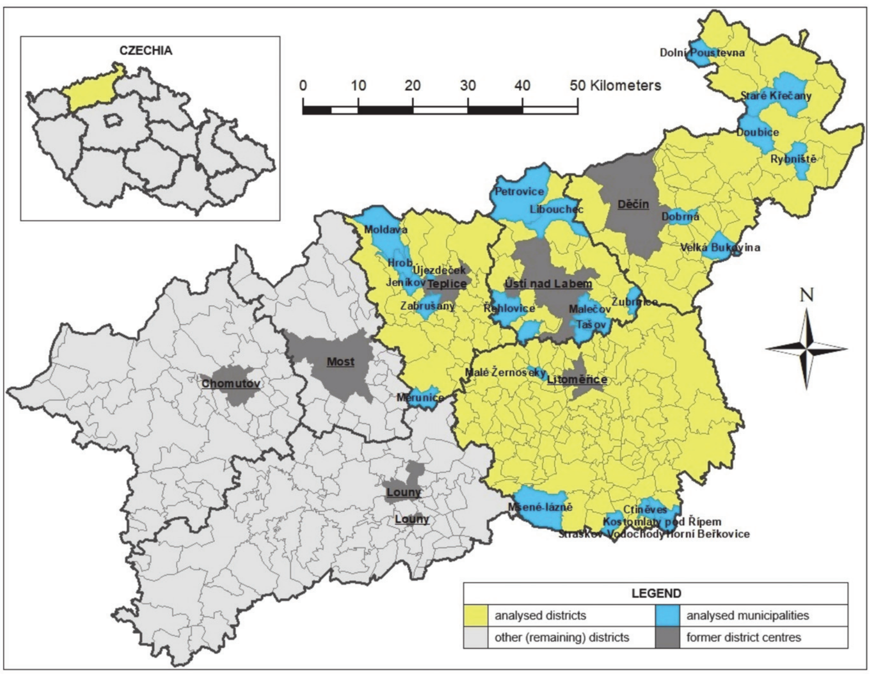

Figure 1. Map of the Ústí Region, showing districts and municipalities where the fieldwork took place.

The interview consisted of 11 questions in total, of which four were the primary focus of this analysis, being directly related to the research questions. The remaining seven queries were of secondary importance, being of an auxiliary and supplementary character. The four primary questions, which are analysed in the subsequent section of this article, were as follows:

- Can you estimate how many citizens from your municipality participated in preparing the land-use plan?
- Do you consider civic participation a necessary element of the land-use planning process? If so, in what areas is civic participation important and impactful? What is its irreplaceable role?
- Can civic participation be counterproductive or detrimental (damaging) to some aspects of the land-use planning process? If so, in which aspects or areas?
- Would land-use planning be possible without any civic involvement at all? Why?

Table 1. Overview of the respondents.

Municipality	Population as of 31 December 2018	Date of Interview	Interview Provided By	Sex	Age Group	In Office (Number of Terms)	Full Time
Ctiněves	336	21 September 2019	mayor	male	45–64	3 or more	no
Dobrná	436	11 September 2019	mayor	male	30–44	1	yes
Dolní Poustevna	1732	7 August 2019	deputy mayor	male	30–44	3 or more	yes
Doubice	112	31 July 2019	mayor	male	30–44	2	no
Horní Beřkovice	930	28 August 2019	mayor	male	45–64	2	yes
Hrob	1998	26 August 2019	mayor	male	45–64	1	yes
Jeníkov	856	4 September 2019	mayor	female	45–64	1	yes
Kostomlaty pod Řípem	440	4 September 2019	mayor	male	65+	1	no
Libouchec	1835	19 August 2019	mayor	male	45–64	2	yes
Malečov	817	26 August 2019	mayor	male	45–64	3 or more	yes
Malé Žernoseky	719	29 July 2019	mayor	male	45–64	3 or more	yes
Měrunice	303	4 September 2019	mayor	female	30–44	3 or more	yes
Moldava	192	9 September 2019	mayor	male	30–44	1	yes
Mšené Lázně	1790	12 August 2019	mayor	male	65+	2	yes
Petrovice	883	21 August 2019	mayor	male	45–64	3 or more	yes
Rybniště	665	22 August 2019	deputy mayor	female	30–44	2	yes
Řehlovice	1435	8 August 2019	mayor	female	30–44	1	yes
Staré Křečany	1260	2 September 2019	mayor	male	45–64	3 or more	yes
Straškov-Vodochody	1070	19 August 2019	mayor	male	30–44	1	yes
Tašov	151	12 September 2019	mayor	male	45–64	1	no
Újezdeček	887	23 July 2019	deputy mayor	male	45–64	3 or more	yes
Velká Bukovina	507	28 August 2019	mayor	male	45–64	3 or more	yes
Zabrušany	1143	24 July 2019	mayor	male	30–44	1	yes
Zubrnice	239	7 August 2019	mayor	male	45–64	3 or more	no

4. Results

The mayors first assessed the degree of participation in the land-use planning process in their municipality, identifying three levels of participation with regard to quantity. The first level is high, with more than 50% of the population taking part in the process, though such a high degree is rare, only being claimed by two of the 24 respondents. This was referred to as “The majority, more than half,” with one mayor describing the highest possible level of participation as follows: “It seemed like everyone here was part of it, and I think it really was a 100% participation. We started off with a person requesting a change, and then we had a petition come up here with dozens of signatures protesting the architect’s design.” In 14 municipalities, the mayors estimated public engagement as medium, that is, including the involvement of groups amounting to dozens of inhabitants: “Participation was in the dozens. I’d say that the number of people was based on how much it involved the needs of the people who had some idea of what the land-use plan was and what it meant.” In the remaining eight municipalities, the mayors described participation as low, that is, with only a few individuals engaged: “I could count the participants here on the fingers of one hand” and “ . . . we had some requests from one or two citizens at the beginning, but no one took part afterwards.” The experience varies significantly from one municipality to another, ranging from practically zero participation by citizens to practically the whole municipality becoming involved. Therefore, it is not possible to specify a typical degree of participation in low-population municipalities, and it is evident that the degree of participation depends on the particularities of each municipality.

With regard to the importance or necessity of participation for land-use planning, the mayors most frequently mentioned that involvement in the land-use planning process allowed citizens to take part in the territorial development of their municipality: “ . . . if I live in some place, participation allows me to join in to what will be there in the future, what is planned there . . . ”, thus shaping the municipality and its territory in the future. Additionally, one mayor state the following: “Participation is essential, the land-use plan is a project related to the development of the municipality and its surroundings, for the future and for its long-term perspectives . . . ”. Participation may also introduce interesting ideas and proposed solutions for the territory: " . . . as the saying goes, 'two heads are better than one,' so you can have people with some good idea and good concept for a change within the territory," and "no one is wise in all ways, so another person's opinion and another point of view can be beneficial." Participation is a major aid to both experts-planners, who are executing the land-use planning process, and to local politicians: "You can have a solid leadership, experts for preparing the land-use plan, but there has to be participation, because the citizens see how the territory develops, and the politicians and planners can easily miss something . . . ". Additionally, if citizens enter the process, the resulting land-use plan can be adjusted according to their actual needs: "You can't set the way of life here properly without the public, of course you can't please everyone, but you won't find anything out without the citizens." Last but not least, participation is an attribute of democratic society in the sense that citizens have the option to co-decide the shape of the land-use plan, thus actually impacting the future of their municipality: "It's main importance is in the citizens' right to be able to express themselves; for the citizen to be content, he should have the right to expression." All mayors responded in the affirmative to the question of whether participation is essential, and none of the respondents claimed that they considered participation to be unnecessary for land-use planning.

With regard to the negative impacts of participation, the mayors pointed to the advancement of individual intentions, which are often less than beneficial to the municipality as a whole—" . . . in those cases when the personal interests of a citizen are not beneficial to the municipality and are not in accordance with its interests and strategies"—with the only profit going to the person who made the proposal. This can stem from endeavors aimed at self-enrichment or efforts to boost the appreciation of one's property: " . . . there is always a lot of lobbying for the appreciation of properties, but I've already seen elsewhere how it was appreciated and subsequently sold." Citizens may also be too strongly focused on the short-term perspective: "People often think of their short-term purpose, but they don't see further ahead. It's hard to explain to them that everything will be completely different in a few years' time." Another potential factor is a bad grasp of what land-use planning actually is and how it works: " . . . sometimes the ignorance of the fact that the land-use plan deals with the municipality as a whole and not with individual ownership pleas; most people don't realise that and only try to protect their own interests." Participation can also easily lead to delays: " . . . for instance, if you don't satisfy someone's demands, he can appeal and protest, and that can make the whole process take longer." Participatory tools can also be used negatively to create obstructions that do not even have to be related to the issue of land-use planning, but can merely be abused for the purpose of advancing someone's interests in other matters and for gaining attention: " . . . if someone abuses the option of participation and there is no justification to it, or if they just block something from their own one-sided perspective . . . one person can block the development of the whole municipality." Public involvement can also introduce a number of unrealistic demands for changes to the territory and its facilities, or foster resistance to necessary limitations: " . . . so we all want to have water, gas, electricity everywhere, possibly other things for a good quality of living, but on the other hand no one wants any kind of limitations.". Furthermore, a high level of engagement can aggravate emotions, leading to escalated tensions in negotiations and consequently impacting the whole process of land-use planning: " . . . it happens that if we have a work meeting where emotions get out of hand, the problem is escalated, and that can influence all the participants of course . . . from my own experience, I know that it is difficult to calm the situation, and things can go against the public interest." Only two of the interviewed mayors reckoned that there was no negative side to participation.

Finally, the mayors were questioned about the possibility of completely removing civic participation from the land-use planning process. This option was categorically refused by two thirds of all mayors, who argued that the land-use plan is an instrument that will influence the future operations of the municipality: " . . . it is a document which we will be working with here for as much as twenty years, and so I reckon it is important to have the citizens involved." They also mentioned that participation is a feature of democracy and "bottom-up" planning: " . . . if we excluded society, we'd be going back several decades to Socialist times . . . ". They noted that the plan impacted both council property—" . . . council land are property of the council, and so every citizen of the municipality has the right to voice their opinion . . . "—and the private property of individual inhabitants—" . . . you can't do it without participation because with regard to the inhabitants it often affects their ownership rights." Some of the mayors acknowledged that land-use planning could be conducted without public involvement, as a purely expert endeavor, but they immediately countered that this would not benefit the overall quality of the plan: " . . . I guess you could do it without the people, but that would be wrong . . . the land-use plan serves the citizens, and so everyone should have the option to have their say." One mayor declared that the exclusion of citizens would only be possible if " . . . the plan was being made only for the needs of the council and council land and in no way affected private property." All in all, it can be stated that none of the mayors categorically claimed that it would be possible to exclude the public from the land-use planning process. When some of them did admit this as a possibility, they subsequently added that it would have a negative impact on the planning, or they stipulated specific conditions that would be required. The quantified responses in individual categories are summarized in Table 2.

Table 2. Quantified categorization of responses to the four main research questions.

Degree of public participation in the land-use planning process				
high (maximal)—majority, more than 50% of inhabitants		medium—groups, dozens of inhabitants		low (minimal)—only a few individuals
2 municipalities; 8.34%		14 municipalities; 58.3%		8 municipalities; 33.3%
Areas in which civic participation is important and impactful with regard to land-use planning				
taking part in the development and future of the municipality	source of ideas and proposals for individual intentions	supplement to the expert and political perspectives	allows the plan to be adjusted to actual mode of operation (life) in the territory	application of the principle of democracy
11 municipalities; 45.83%	8 municipalities; 33.3%	4 municipalities; 16.7%	4 municipalities; 16.7%	4 municipalities; 16.7%
Areas in which civic participation is counterproductive or detrimental (damaging)				
advancement of individual (private) interests	risk of delays and potential for obstructions	unrealistic demands and refusal of regulation	escalated conflicts—emotional issues	participation has no negatives
11 municipalities; 45.83%	10 municipalities; 41.67%	1 municipality;4.17%	1 municipality 4.17%	2 municipalities;8.34%
Possibility of land-use planning without any public involvement				
not possible		yes, but it would be negative		yes, if the changes only affected council property
16 municipalities; 66.67%		7 municipalities; 29.17%		1 municipality; 4.17%

The results can be summarized in such a way that civic participation provides space for commenting on the planned intentions, which might also result in an intervention that regulates the elaboration of a land-use plan in the place where residents live and whose lives are connected with it. It is beneficial if there are presentations of different, and even very different, opinions, because the presentation of a different opinion, which may be a different view of the matter, can help to form a better final solution. At the same time, it is possible to prevent the fact that, after the approval of the land-use plan, it would not be possible to implement the intentions (usually construction) that people would like because the land-use plan is set differently. Alternatively, some residents (usually older) may provide a retrospective view of how certain things used to work within the municipality before, and the municipality may return to this in some way, in a regime that is adapted to current conditions. By analogy, residents who previously lived elsewhere (at least temporarily) can bring insight and experience from another place to the planning process. Social control is also very important as it can cover the shortcomings that may arise. Such shortcomings might be missed by experienced professionals, in spite of good management of the municipality, because they do not have personal experience with (even minor) problems faced by everyday users of the place, while municipality management may suffer from the so-called operational blindness. Last but not least, civic participation is an important element of democracy, as citizens have the right to engage in both their own intentions and lands, as well as in the area of public intentions and lands.

5. Discussion

The research confirmed that participation in the land-use planning process helps identify areas where there is a risk of potential conflict in the use of the territory [28]. At the same time, it confirmed that every participatory tool has negative effects [11], as municipal authorities frequently come up against participatory bias [48] when individuals or groups advance their own interests: " . . . this was mainly those citizens who somehow wanted to change the class of their property." If there are many such proposals, it can negatively impact the process by delaying it considerably. However, if the citizens' suggestions are factual, it is an example of positive engagement, which allows the citizens to increase their awareness of land-use planning and is conducive to collaborative education [3–5]. Citizen proposals that are denied pose a certain risk, however, as " . . . those people feel that their needs weren't heard out, so then they turn to the other side, which can reflect negatively on to the next phase of planning," so it is important to communicate with citizens [13]; experts must thus be able to negotiate [43]. However, even denied applications are valuable, as the issues at hand may be properly discussed during the preparation of the land-use plan, consequently avoiding later protests of citizens dissatisfied with the planned intentions of their local government [30]. Furthermore, even rejected proposals may bring about synergic effects. If the citizens' suggestions are accepted, it generally leads to a greater level of contentment with the solutions applied by the land-use plan [2,58]. It is also important to evaluate whether participation is relevant and beneficial to a given intention [10], as this might not always be the case, for example, with regard to hard infrastructure: " . . . that is then the task of experts and us as the municipal authority, to what extent we set the participation and how the information is used". This involves the positive factor of facilitating discussion between the involved parties [6] and of disseminating information about land-use planning, as citizens are only able to plan effectively and correctly if they are sufficiently informed about the given territory [12].

The research did not confirm that participation in land-use planning in the analysed municipalities was of a merely pro-forma character [37] or that its importance was underestimated by politicians and experts: [40] " . . . you can't just have the outside perspective . . . ". On the other hand, it was confirmed that participatory mechanisms are institutionalized to a lesser degree than would be suitable [38], which is caused, among other factors, by the absence of methodological frameworks that would support participation in the planning process: [45] " . . . so then it's up to the council to get it out among the people and for them to realise that it's part of the development of the municipality". In relation to this point, some of the municipalities recognized their limitations: " . . . we lagged behind in our efforts to spread among the people how important the plan is and what it means." It is a considerable challenge for both local authorities and experts to take the proposals of citizens into account and implement them where applicable [37,41]: " . . . the contracting authority should somehow come to terms with the material considerations, so the opinions of those people are taken seriously and properly assessed." One problematic area with untapped potential is that municipalities generally rely solely on voluntary participation and do not actively seek information by other means [52], although it can be seen as positive that local governments seek informal negotiations and channels for informing about land-use planning, for example, in the form of local bulletins, informal work meetings, or the municipal broadcast.

An important issue that would facilitate the definition of the optimal level of civic participation would be the identification of factors that influence the level of public involvement, both positively and negatively. The stimulus for involvement in land-use planning is often some personal benefit, which relates to the effort to promote one´s interest, or to evaluate one´s property [23]. Therefore, it is important to look for ways to strengthen participation in matters concerning the municipality as a whole. Since something can be created or changed through participation, it is important that it also functions as a social control [70]. It is likely that the overall level of public involvement is significantly influenced by the social factors that determine how a society operates. If there is a low level of participation in the municipality for a long time and a general lack of interest in public affairs, then this state can become a natural state of the place. Closely related to this is collaborative learning [3–5], which can work for an individual in such a way that if people around them are interested in the matter, they will also be interested in it as well, because it is probably important. Of course, the whole thing can work the other way around—if no one around an individual shows interest in something, it is normal and the individual will not behave differently. This is associated with collective action [71] and the ability to cooperate in the community [35], both of which are further linked to social cohesion [54,72]. However, it would be difficult to find ways to do this, especially for municipalities where interest in public affairs is traditionally small, and a possible solution may be to profile a leader [73]. This individual would be the main leader for the issue and would be able to attract other residents and arouse interest in the matter at hand. Ideally, the role of the leader would be performed by the mayor or another important representative of the municipality.

The combination of traditional and modern tools is suitable for strengthening civic participation. It does not only have to involve the usual simplistic view that traditional tools are for the elderly and modern tools are for the young, as it is a matter of allowing everyone to choose what suits them. As a result, the citizens will feel comfortable using the tool and they can be expected to provide sufficient feedback within their individual possibilities. However, it is important to look for ways to suppress participatory bias throughout the process [48,51], because, if the level of participation is low and only those who want to achieve something and pursue their individual intention are involved, it can be very negative for the community. In addition, it is important not to rely on the voluntary participation of citizens [52], but to really use the knowledge from the public, not just to encourage participation, but also to create opportunities for involvement [70]. The municipality can also use the so-called web 2.0 for obtaining observations [52], which is easily accessible with the current massive development of social networks, so the municipality can continuously monitor feedback and problems. However, especially in small municipalities, it can be problematic to allocate personnel capacities to this activity.

6. Conclusions

In the field of land-use planning, civic participation provides space for residents to be significantly involved, but engagement requires social cohesion and its strengthening [72]. Residents can be involved in terms of their own individual intentions, for example, if they want to change the usability of land so that they can build what they plan. Additionally, they can influence projects in their immediate vicinity that may affect their property, as well as general and complex intentions, which relate to a vision for the future in the sense of "where we are and where we are going", and in this respect, a plurality of opinions is important. The participation of citizens in the vision for the future, which will be ensured by the appropriate development of the land-use plan, is suitable due to the fact that citizens thus become participants in the project, which, from a territorial point of view, will greatly affect the functioning of the municipality in the future. On the positive side of civic participation, citizens can "build their place" through it, and if they identify with the land-use plan and adopt it as their own, they are likely to be more inclined to be satisfied with it. However, in order for this to work, it has been confirmed that it is usually necessary to take collective action and take steps towards social learning [71], and the profiling and follow-up of the leader (Lamker) can be a significant driving force in this direction [73]. Among other things, civic participation is important as a source of observations and ideas for individual intentions, while social control can also take place [70].

Civic participation is a major component of the land-use planning process, which is generally executed by experts via a political contracting authority. Civic participation has an irreplaceable role in supplementing expert knowledge and planning [9] with the "know-how" of local inhabitants [29]. The optimal degree of civic participation in land-use planning cannot be defined in a universally applicable manner, but it is possible to describe a number of its typical basic features. An optimal degree of civic participation (1) should constitute a representative sample of the population that inhabits the given territory—individuals are not enough, whilst a 50% or higher level of involvement is not completely necessary, but groups of dozens of people may be sufficient if (2) these groups are well balanced and represent various population segments (young X old; employees X entrepreneurs; healthy X ill, etc.). Additionally, these groups may sufficient if (3) they bring relevant proposals from the citizens, which can be and are accepted, but also other impulses that are not or cannot be satisfied, and if they also allow individual citizens or groups to express themselves and enter into debate, which promotes awareness of the issue and facilitates collaborative education [3–5], thus providing the municipality with a more educated and experienced citizenry and promoting a civil society [59] with a greater future potential for participation. However, participatory bias [48] must always be taken into account as a negative external attribute.

The recommendations that can ensure and facilitate an optimal degree of civic participation in land-use planning may be summarized in the following points.

1. Do not prefer only voluntary participation, but actively obtain information as the contracting party [52]. For example, targeted surveys that encompass all population groups and types of households should be conducted, which may identify different preferences than those of voluntary participants. Although it is very difficult to representatively assess every segment of the population in practice, every effort in that direction is beneficial and boosts diversity of knowledge;
2. Engage inhabitants with multiple instruments at once. Do not only apply those means that are mandated by law [23]. A diversity of utilized participatory tools can help increase the level of participation, as every individual or group may be better suited to something different [60]; for example, older citizens may prefer to receive information through personal contact, a municipal broadcast, or from classical (physical) official noticeboards, and they may prefer to give feedback verbally or via a paper questionnaire, whereas younger inhabitants obtain information through the internet and social networks and readily provide feedback online. Younger generations generally evince a lower degree of participation [53], and this limitation can be potentially overcome by the use of modern channels [52,65]. It is also useful to allow participants to evaluate the participatory tools they use [74];
3. Organize regular educational activities, consistently communicate, and give feedback. The municipal authority should strive to actively disseminate information regarding the importance of land-use planning and its direct impact on the future development of the municipality, regarding the various means of participation and the importance thereof, so that, in the best case scenario, the inhabitants would in effect take ownership of the planning process [58]. Furthermore, individual intentions and proposals should be consistently communicated, regardless of whether they were implemented, in order to provide participants with feedback [25];
4. Seek informal channels of communication and discussion. If it is practically possible, organize informal meetings, which may have a more relaxed atmosphere, thus gaining new impulses. Another option is to complement the use of official documents with unofficial ones which—though being merely informative—are much more accessible to the ordinary citizen. These may take on the form of brief notices on the municipality's

website, or an article in a bulletin published by the local council, perhaps structured as an interview with the mayor or with the expert who is preparing the plan.

This research deals with the optimal level of civic participation, which should be an important element for land-use planning in terms of quality. This distinguishes the present study from most professional studies, which also deal with the topic of civic participation, as they usually address the quantitative aspect, i.e., how to strengthen public participation and gain more knowledge from the public for land-use planning. However, they almost never offer solutions for producing an effective participation process. Another important group of publications focuses on civic participation in terms of the positive and negative aspects of land-use planning. Further research could focus on the citizens' motivation to become involved in the land-use planning process and on identifying the factors that might boost participation, bearing in mind that [25] notes how important it is for participants to receive feedback on how their input was used, so this aspect should also be scrutinized in further detail. Moreover, considering that the scope of the research was limited to municipalities with a small population, it would suitable and beneficial to perform a comparison with larger-population municipalities and cities, or to investigate and identify the characteristic features of voluntary participants. Last but not least, this research was only based on the evaluation of municipal representatives, i.e., individual mayors, so it would be very beneficial to evaluate the optimal level of civic participation from the perspective of planners and the public, or their representatives, in other research.

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References

1. Nabatchi, T.; Amsler, L.B. Direct Public Engagement in Local Government. *Am. Rev. Public Adm.* **2014**, *44*, 63S–88S. [CrossRef]
2. Jacquet, J.B. The Rise of "Private Participation" in the Planning of Energy Projects in the Rural United States. *Soc. Nat. Resour.* **2014**, *28*, 231–245. [CrossRef]
3. Natarajan, L. Socio-spatial learning: A case study of community knowledge in participatory spatial planning. *Prog. Plan.* **2017**, *111*, 1–23. [CrossRef]
4. Bradley, Q. The political identities of neighbourhood planning in England. *Space Polity* **2015**, *19*, 97–109. [CrossRef]
5. Elbakidze, M.; Dawson, L.; Andersson, K.; Axelsson, R.; Angelstam, P.; Stjernquist, I.; Teitelbaum, S.; Schlyter, P.; Thellbro, C. Is spatial planning a collaborative learning process? A case study from a rural-urban gradient in Sweden. *Land Use Policy* **2015**, *48*, 270–285. [CrossRef]
6. Wilker, J.; Rusche, K.; Rymsa-Fitschen, C. Improving Participation in Green Infrastructure Planning. *Plan. Pract. Res.* **2016**, *31*, 229–249. [CrossRef]
7. Sutton, A. Living the good life: A meta-analysis of authenticity, well-being and engagement. *Personal. Individ. Differ.* **2020**, *153*, 109645. [CrossRef]
8. McCall, M.K.; Dunn, C.E. Geo-information tools for participatory spatial planning: Fulfilling the criteria for 'good' governance? *Geoforum* **2012**, *43*, 81–94. [CrossRef]
9. Tennøy, A.; Hansson, L.; Lissandrello, E.; Næss, P. How planners' use and non-use of expert knowledge affect the goal achievement potential of plans: Experiences from strategic land-use and transport planning processes in three Scandinavian cities. *Prog. Plan.* **2016**, *109*, 1–32. [CrossRef]
10. Nyseth, T.; Ringholm, T.; Agger, A. Innovative Forms of Citizen Participation at the Fringe of the Formal Planning System. *Urban Plan.* **2019**, *4*, 7–18. [CrossRef]

11. Gaventa, J.; Barrett, G. Mapping the Outcomes of Citizen Engagement. *World Dev.* **2012**, *40*, 2399–2410. [CrossRef]
12. Zysk, E.; Dawidowicz, A.; Źróbek, S.; Źróbek, R. The concept of a geographic information system for the identification of degraded urban areas as a part of the land administration system—A Polish case study. *Cities* **2020**, *96*, 102423. [CrossRef]
13. Damurski, Ł.; Oleksy, M. Communicative and participatory paradigm in the European territorial policies. A discourse analysis. *Eur. Plan. Stud.* **2018**, *26*, 1471–1492. [CrossRef]
14. Wang, H.; Shen, Q.; Tang, B. GIS-Based Framework for Supporting Land Use Planning in Urban Renewal: Case Study in Hong Kong. *J. Urban Plan. Dev.* **2015**, *141*, 05014015. [CrossRef]
15. Brown, G.; Raymond, C.M. Methods for identifying land use conflict potential using participatory mapping. *Landsc. Urban Plan.* **2014**, *122*, 196–208. [CrossRef]
16. Fürst, C.; Opdam, P.; Inostroza, L.; Luque, S. Evaluating the role of ecosystem services in participatory land use planning: Proposing a balanced score card. *Landsc. Ecol.* **2014**, *29*, 1435–1446. [CrossRef]
17. Hersperger, A.M.; Franscini, M.P.G.; Kübler, D. Actors, Decisions and Policy Changes in Local Urbanization. *Eur. Plan. Stud.* **2014**, *22*, 1301–1319. [CrossRef]
18. von der Dunk, A.; Grêt-Regamey, A.; Dalang, T.; Hersperger, A.M. Defining a typology of peri-urban land-use conflicts—A case study from Switzerland. *Landsc. Urban Plan.* **2011**, *101*, 149–156. [CrossRef]
19. Martínez, M. The Citizen Participation of Urban Movements in Spatial Planning: A Comparison between Vigo and Porto. *Int. J. Urban Reg. Res.* **2011**, *35*, 147–171. [CrossRef]
20. Bourgoin, J.; Castella, J.C.; Pullar, D.; Lestrelin, G.; Bouahom, B. Toward a land zoning negotiation support platform: "Tips and tricks" for participatory land use planning in Laos. *Landsc. Urban Plan.* **2012**, *104*, 270–278. [CrossRef]
21. Meilvang, M.L.; Carlsen, H.B.; Blok, A. Methods of engagement: On civic participation formats as composition devices in urban planning. *Eur. J. Cult. Political Sociol.* **2018**, *5*, 12–41. [CrossRef]
22. Eiter, S.; Vik, M.L. Public participation in landscape planning: Effective methods for implementing the European Landscape Convention in Norway. *Land Use Policy* **2015**, *44*, 44–53. [CrossRef]
23. Kopáček, M. Civic Engagement in the Process of Land Use Planning: Case Study of Small Municipalities in the Czech Republic. *Geogr. Cassoviensis* **2019**, *13*, 36–52. [CrossRef]
24. Chabot, M.; Duhaime, G. Land-use planning and participation. *Habitat Int.* **1998**, *22*, 429–447. [CrossRef]
25. Kyttä, M.; Broberg, A.; Haybatollahi, M.; Schmidt-Thomé, K. Urban happiness: Context-sensitive study of the social sustainability of urban settings. *Environ. Plan. B Plan. Des.* **2015**, *43*, 34–57. [CrossRef]
26. Golobiĉ, M.; Maruŝiĉ, I. Developing an Integrated Approach for Public Participation: A Case of Land-Use Planning in Slovenia. *Environ. Plan. B Plan. Des.* **2007**, *34*, 993–1010. [CrossRef]
27. Nunbogu, A.M.; Korah, P.I.; Cobbinah, P.B.; Poku-Boansi, M. Doing it 'ourselves': Civic initiative and self-governance in spatial planning. *Cities* **2018**, *74*, 32–41. [CrossRef]
28. Brown, G.; Sanders, S.; Reed, P. Using public participatory mapping to inform general land use planning and zoning. *Landsc. Urban Plan.* **2018**, *177*, 64–74. [CrossRef]
29. Glackin, S.; Dionisio, M.R. 'Deep engagement' and urban regeneration: Tea, trust, and the quest for co-design at precinct scale. *Land Use Policy* **2016**, *52*, 363–373. [CrossRef]
30. Eshuis, J.; Klijn, E.H.; Braun, E. Place marketing and citizen participation: Branding as strategy to address the emotional dimension of policy making? *Int. Rev. Adm. Sci.* **2014**, *80*, 151–171. [CrossRef]
31. Koontz, T.M.; Newig, J. From Planning to Implementation: Top-Down and Bottom-Up Approaches for Collaborative Watershed Management. *Policy Stud. J.* **2014**, *42*, 416–442. [CrossRef]
32. Nenko, A.; Parkins, J.R.; Reed, M.G.; Sinclair, A.J. Rethinking Effective Public Engagement in Sustainable Forest Governance. *Soc. Nat. Resour.* **2019**, *32*, 1383–1398. [CrossRef]
33. Bąkowska-Waldmann, E.; Kaczmarek, T. The Use of Geo-Questionnaire in Spatial Planning. *Int. J. E Plan. Res.* **2019**, *8*, 45–67. [CrossRef]
34. Martinelli, M.A.; Achcar, J.A.; Machado Hoffmann, W.A. Cidades inteligentes e humanas: Percepção local e aderência ao movimento que humaniza projetos de smart cities. *Rev. Tecnol. E Soc.* **2020**, *16*. [CrossRef]
35. Henry, A.D.; Lubell, M.; McCoy, M. Belief Systems and Social Capital as Drivers of Policy Network Structure: The Case of California Regional Planning. *J. Public Adm. Res. Theory* **2011**, *21*, 419–444. [CrossRef]
36. Santos, B. Improving Urban Planning Information, Transparency and Participation in Public Administrations. *Int. J. E Plan. Res.* **2017**, *6*, 58–75. [CrossRef]
37. Nared, J.; Razpotnik Visković, N.; Cremer-Schulte, D.; Brozzi, R.; Cortines Garcia, F. Achieving sustainable spatial development in the Alps through participatory planning. *Acta Geogr. Slov.* **2015**, *55*. [CrossRef]
38. Häkli, J.; Kallio, K.P.; Ruokolainen, O. A Missing Citizen? Issue Based Citizenship in City-Regional Planning. *Int. J. Urban Reg. Res.* **2019**. [CrossRef]
39. Eshkol, B.; Eshkol, A. Participatory planning in Israel: From theory to practice. *J. Place Manag. Dev.* **2017**, *10*, 213–239. [CrossRef]
40. Tudor, C.A.; Iojă, I.C.; Pătru-Stupariu, I.; Nită, M.R.; Hersperger, A.M. How successful is the resolution of land-use conflicts? A comparison of cases from Switzerland and Romania. *Appl. Geogr.* **2014**, *47*, 125–136. [CrossRef]
41. Kahila-Tani, M.; Broberg, A.; Kyttä, M.; Tyger, T. Let the Citizens Map-Public Participation GIS as a Planning Support System in the Helsinki Master Plan Process. *Plan. Pract. Res.* **2016**, *31*, 195–214. [CrossRef]

42. Curry, N. Community Participation in Spatial Planning: Exploring Relationships between Professional and Lay Stakeholders. *Local Gov. Stud.* **2012**, *38*, 345–366. [CrossRef]
43. Blicharska, M.; Angelstam, P.; Antonson, H.; Elbakidze, M.; Axelsson, R. Road, forestry and regional planners' work for biodiversity conservation and public participation: A case study in Poland's hotspot regions. *J. Environ. Plan. Manag.* **2011**, *54*, 1373–1395. [CrossRef]
44. Hofmann, M.; Westermann, J.R.; Kowarik, I.; van der Meer, E. Perceptions of parks and urban derelict land by landscape planners and residents. *Urban For. Urban Green.* **2012**, *11*, 303–312. [CrossRef]
45. Hewitt, R.; Escobar, F. The territorial dynamics of fast-growing regions: Unsustainable land use change and future policy challenges in Madrid, Spain. *Appl. Geogr.* **2011**, *31*, 650–667. [CrossRef]
46. Mierzejewska, L. Sustainable Development of a City: Systemic Approach. *Probl. Ekorozw. Probl. Sustain. Dev.* **2017**, *12*, 71–78.
47. Shaker, R.R.; Sirodoev, I.G. Assessing sustainable development across Moldova using household and property composition indicators. *Habitat Int.* **2016**, *55*, 192–204. [CrossRef]
48. Brown, G.; Strickland-Munro, J.; Kobryn, H.; Moore, S.A. Stakeholder analysis for marine conservation planning using public participation GIS. *Appl. Geogr.* **2016**, *67*, 77–93. [CrossRef]
49. Han, Y.; Huang, Q.; He, C.; Fang, Y.; Wen, J.; Gao, J.; Du, S. The growth mode of built-up land in floodplains and its impacts on flood vulnerability. *Sci. Total Environ.* **2020**, *700*, 134462. [CrossRef] [PubMed]
50. López-Martínez, F.; Pérez-Morales, A.; Illán-Fernández, J.E. Are local administrations really in charge of flood risk management governance? The Spanish Mediterranean coastline and its institutional vulnerability issues. *J. Environ. Plan. Manag.* **2020**, *63*, 257–274. [CrossRef]
51. Chiodelli, F.; Moroni, S. Corruption in land-use issues: A crucial challenge for planning theory and practice. *Town Plan. Rev.* **2015**, *86*, 437–455. [CrossRef]
52. Brown, G.; Kelly, M.; Whitall, D. Which 'public'? Sampling effects in public participation GIS (PPGIS) and volunteered geographic information (VGI) systems for public lands management. *J. Environ. Plan. Manag.* **2014**, *57*, 190–214. [CrossRef]
53. David, N.P.; Buchanan, A. Planning Our Future: Institutionalizing Youth Participation in Local Government Planning Efforts. *Plan. Theory Pract.* **2020**, *21*, 9–38. [CrossRef]
54. Esmaeilpoorarabi, N.; Yigitcanlar, T.; Kamruzzaman, M.; Guaralda, M. How can an enhanced community engagement with innovation districts be established? Evidence from Sydney, Melbourne and Brisbane. *Cities* **2020**, *96*, 102430. [CrossRef]
55. Bjärstig, T.; Thellbro, C.; Stjernström, O.; Svensson, J.; Sandström, C.; Sandström, P.; Zachrisson, A. Between protocol and reality—Swedish municipal comprehensive planning. *Eur. Plan. Stud.* **2017**, *26*, 35–54. [CrossRef]
56. Blomley, N. Land use, planning, and the "difficult character of property". *Plan. Theory Pract.* **2017**, *18*, 351–364. [CrossRef]
57. Delitheou, V.; Bakogiannis, E.; Kyriakidis, C. Urban planning: Integrating smart applications to promote community engagement. *Heliyon* **2019**, *5*, e01672. [CrossRef]
58. Martinaityte, I.; Unsworth, K.L.; Sacramento, C.A. Is the project 'mine' or 'ours'? A multilevel investigation of the effects of individual and collective psychological ownership. *J. Occup. Organ. Psychol.* **2020**, *93*, 302–327. [CrossRef]
59. Horst, C.; Erdal, M.B.; Jdid, N. The "good citizen": Asserting and contesting norms of participation and belonging in Oslo. *Ethn. Racial Stud.* **2020**, *43*, 76–95. [CrossRef]
60. Afzalan, N.; Muller, B. Online Participatory Technologies: Opportunities and Challenges for Enriching Participatory Planning. *J. Am. Plan. Assoc.* **2018**, *84*, 162–177. [CrossRef]
61. Kaczmarek, T.; Wójcicki, M. Participation in Public Consultations on Spatial Planning Documents. The Case of Poznań City. *Quaest. Geogr.* **2016**, *35*, 71–81. [CrossRef]
62. Brown, G.; Kyttä, M. Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. *Appl. Geogr.* **2014**, *46*, 122–136. [CrossRef]
63. Karimi, A.; Brown, G.; Hockings, M. Methods and participatory approaches for identifying social-ecological hotspots. *Appl. Geogr.* **2015**, *63*, 9–20. [CrossRef]
64. Wolf, I.D.; Wohlfart, T.; Brown, G.; Lasa, A.B. The use of public participation GIS (PPGIS) for park visitor management: A case study of mountain biking. *Tour. Manag.* **2015**, *51*, 112–130. [CrossRef]
65. Zolkafli, A.; Brown, G.; Liu, Y. An Evaluation of the Capacity-building Effects of Participatory GIS (PGIS) for Public Participation in Land Use Planning. *Plan. Pract. Res.* **2017**, *32*, 385–401. [CrossRef]
66. Czepkiewicz, M.; Jankowski, P.; Młodkowski, M. Geo-questionnaires in urban planning: Recruitment methods, participant engagement, and data quality. *Cartogr. Geogr. Inf. Sci.* **2017**, *44*, 551–567. [CrossRef]
67. Hendl, J.; Remr, J. *Metody Výzkumu a Evaluace*; Portál: Prague, Czech Republic, 2017; pp. 137–169.
68. Czech Statistical Office—Public Database. Available online: https://vdb.czso.cz/vdbvo2/faces/en/index.jsf (accessed on 18 April 2019).
69. Thomas, E.; Riley, M.; Spees, J. Knowledge flows: Farmers' social relations and knowledge sharing practices in 'Catchment Sensitive Farming'. *Land Use Policy* **2020**, *90*, 104254. [CrossRef]
70. Aitken, M. A three-dimensional view of public participation in Scottish land-use planning: Empowerment or social control? *Plan. Theory* **2010**, *9*, 248–264. [CrossRef]
71. Castella, J.C.; Bourgoin, J.; Lestrelin, G.; Bounthanom, B. A model of the science–practice–policy interface in participatory land-use planning: Lessons from Laos. *Landsc. Ecol.* **2014**, *29*, 1095–1107. [CrossRef]

72. Rashidfarokhi, A.; Yrjänä, L.; Wallenius, M.; Toivonen, S.; Ekroos, A.; Viitanen, K. Social sustainability tool for assessing land use planning processes. *Eur. Plan. Stud.* **2018**, *26*, 1269–1296. [CrossRef]
73. Lamker, C. Leadership roles in local land-use planning for noise control. *Town Plan. Rev.* **2019**, *90*, 275–297. [CrossRef]
74. Arciniegas, G.; Janssen, R. Spatial decision support for collaborative land use planning workshops. *Landsc. Urban Plan.* **2012**, *107*, 332–342. [CrossRef]

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Article

A Proposed Land Exchange Algorithm for Eliminating the External Plot Patchwork

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Abstract: In many countries of the world, rural areas are characterized by a defective spatial structure of agricultural land. The most frequent defects are large fragmentation and distribution of farmland. The fragmentation of land has been an issue widely described by many authors throughout the world. The problem of the distribution of land owned by individual farmers is slightly different, since due to the complexity of the problem this issue was not widely explored in Poland (plot patchwork) or in other countries of Europe and the world. Land fragmentation and distribution of plots in rural areas has a negative effect on the profitability and efficiency of agricultural production. Land consolidation and exchange is an operation facilitating spatial structure improvement. The authors attempted to develop a universal land exchange algorithm for eliminating the external plot patchwork. As it turns out, so far no land exchange algorithm has been developed. Specific analyses were carried out in Puchaczów commune, county of Łęczna, Lublin voivodeship in the eastern part of Poland, covering an area of 6907.80 ha, split into 15,211 plots. The chequerboard arrays method was used. The publication presents the algorithm and its practical application using a test sample. A result of the studies is a proposal concerning the exchange of land between landowners in the villages of the commune of Puchaczów. Using the algorithm, the area of individual lands in the commune, after the exchange, will increase by 172.09 ha, which is 2.5% for the area of individual lands, and 1.9% for the commune.

Keywords: spatial analysis; land fragmentation; land consolidation; plot patchwork; rural areas; GIS; algorithm

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1. Introduction

The excessive fragmentation of plots owned by a farm is one of the major factors adversely affecting the profitability of agricultural production [1]. The spatial arrangement of land owned by individual farmers in the rural areas of southern and southeastern Poland, developed by historical processes, is characterized by farms covering a small area of land and made up of fragmented and scattered plots. Fragmentation of plots, or in other words land fragmentation, is discussed both in the domestic literature [2–10] and international references [11–15]. Normally, excessive fragmentation of land has its roots in history and social and economic reality [10]. The present-day plot boundaries are a result of long-term transformations. In the reference literature, four types of land fragmentation are distinguished depending on the type of use, form of ownership, and geometric structure of plots (area, number of plots per farm, plot shape, plot elongation, lack of access to the plot, and distance from the farmer's dwelling) [12]. All the above-mentioned defects have a very negative effect on agricultural production and income derived from such production. This is mainly due to the cost of transport, workload, and losses of crops connected with a small area and unfavourable plot shape [16–19]. However, it cannot be claimed that the fragmentation of land is an adverse phenomenon in all countries. The authors give some examples of where exogenous fragmentation is seen as an advantage. This is the case, for instance, in Ethiopia [20], China [21], and India [22].

In turn, long-term studies in Poland show that the plot patchwork is closely linked to the fragmentation of land (plot patchwork). It is one of the factors negatively affecting the organization, costs, and level of agricultural production [23]. With regard to the administrative division, an internal patchwork (within the limits of the village) and an external one can be distinguished. The external patchwork can occur both between respective villages and between communes, counties, voivodeships, and even between countries [24]. The analysis of the origin of plot patchworks in Poland and in other countries shows that this phenomenon is a result of a long-term historical process. Their emergence and development were a result of various causes of a legal, economic, and socio-economic nature [17,23–25]. The external patchwork is a negative phenomenon manifested in decreased labour efficiency due to time lost for accessing the scattered plots. This increases the cost of transport and, as a consequence, all agricultural production. A term associated with plot patchwork is "non-resident owners", coined by Rabczuk (1968) and later specified by Noga [23]. The division was introduced into local non-resident owners, who are owners whose land is not situated in the analyzed village in which they reside, and out-of-village non-resident owners whose land is situated in the analyzed village but who live elsewhere.

A land surveying tool used for improving the arrangement of land is the operation of consolidation and exchange of land which occurs both in Poland and many countries of Europe and the world: Netherlands [26], Cyprus [12], Slovakia [16], Czech Republic [27], China [28], Finland [29], and Northern Ghana [30], Ethiopia [31], Turkey [32]. Land consolidation is a rural management procedure aimed at creating more favourable management conditions in agriculture and forestry by improving the territorial structure of farms, forests and forestland, reasonable configuration of land, aligning the limits of real properties with the system of water irrigation structures, roads and terrain.

The problem in the procedure of land consolidation and exchange is the fact that consolidation mainly occurs within the administrative boundaries of villages. Then, the land of out-of-village non-resident owners is usually situated at the outer boundary of the village, which does not completely improve the existing plot patchwork of farms. It would be advisable to carry out land consolidation and exchange in a manner ensuring the possibility of land exchange between local non-resident owners. It should be added that in the past (in the years after World War II) exchange of land was carried out almost entirely in order to increase the surface area of land owned by the state or a cooperative. Few works were carried out to eliminate the external plot patchwork.

Such an understanding of the issue gives rise to the objective of this paper being the development and presentation of a universal land exchange algorithm for eliminating the external plot patchwork. The work contains a detailed analysis of the external plot patchwork in the study area. It pays attention to the spatial dimensions of the plot patchwork in developing the methodology of its elimination. The elimination of land, especially that owned by local non-resident owners, in the process of land exchange makes it possible to bring the land situated outside the village closer to the dwelling of the owner of such land. Previous solutions regarding land consolidation works involved only the study of out-of-village non-resident owners that, in principle, provide information about the existing defects but does not eliminate this phenomenon [23].

Study Area

General studies regarding the land of non-resident owners were carried throughout the county of Łęczna [7]. The overall area of the county (district) is 637 km^2 and consists of six communes (communes). The study of the size of land of non-resident owners used the chequerboard arrays method which makes it possible to identify the land of out-of-village non-resident owners and that of local non-resident owners. The analysis covered all villages within the study area and three matrices were prepared for: The area of land, number of plots, and owners. Determining the area covered by the land of non-resident owners is essential to ensure the correct consolidation of land for the purposes of land exchange. The previous land consolidation works involved only a study of out-of-village non-resident owners in the village being consolidated, which does not form a basis for land exchange prior to consolidation. The commune of Puchaczów was selected for further specific surveys.

Specific surveys were carried out in eastern Poland in Lublin voivodeship, county of Łęczna, commune of Puchaczów (Figure 1). The study area is situated east of the city being the seat of the county. It consists of 15 villages. The surface area of the commune is 9158.0 ha, which accounts for 14.4% of the county surface area. The area of the commune is divided into 18,052 plots, each having an average surface area of 0.51 ha. At 31 December 2019, the commune had 5403 residents and a population density of 59 people per 1 km^2, which is less than the mean population density in Lublin voivodeship. The commune was selected on purpose since it is situated within the zone of impact of the municipality of Łęczna (county town) and the village of Bogdanka where a hard coal mine is located. These two locations specified above have a significant impact on the spatial structure of the private land. Therefore, the existing structure of fragmentation and dispersion of plots in the villages of that commune was analyzed in connection with the objective of the surveys, that is, determining the size of the plot patchwork and identifying the possibilities of eliminating the patchwork. The spatial location of the study area is illustrated in Figure 1.

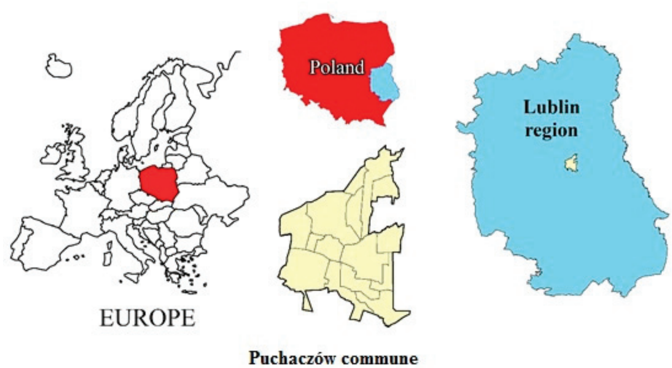

Figure 1. Spatial location of the study area in Poland.

The existing structure of fragmentation and dispersion of plots in the villages of the commune of Puchaczów was analyzed in connection with the objective of the surveys, that is, determining the size of the plot patchwork and identifying the possibilities of eliminating the patchwork. The determination of the size and its treatment revealed possibilities for land exchange. From a technical point of view, it is possible, but the basic criterion was making these possibilities real. In previous consolidation works until 1982, the external patchwork of plots owned by private individuals in the village could not be eliminated in the process of land exchange [33]. With the above-mentioned act, the legislator narrowed the notion of land exchange to the state-controlled economy only (farmer—state-controlled economy). In the process of consolidation, the problem of external plot patchwork was only partly corrected by bringing the land of non-resident owners to the boundaries of the village which they came from. Such solutions not only did not improve the management conditions but also partly deteriorated access to newly subdivided plots.

The act on consolidation and exchange of land [34] allows individuals to exchange their plots. However, the previously completed consolidation works did not involve land exchange, which can also be observed in the study area. In order to accomplish the adopted aim of the study, data from the land and buildings register was used as the study material. The descriptive part of the land and buildings register provided information on: Ownership and use of land, soil quality classes of private agricultural land, number of private land property (register items), and number of plots. In addition, the land register was a source of information on: The number and place of residence of owners, overall surface area of land, and the number of constituent plots (size of land of out-of-village non-resident owners). The cadastral map was used in specific surveys to prepare a study of non-resident owners in two villages. It was a base map for visualizing the spatial distribution of land in the external plot patchwork. In addition, an inventory of all owners whose land is located outside their place of dwelling (external plot patchwork) was made. To this end, the following information was collected: Dwelling place of the owner, overall surface area of land owned, and number of plots.

2. Materials and Methods

The collected database of the analyzed villages was stratified using the chequerboard arrays method, identifying the size of plots of land owned by local and out-of-village non-resident owners. Next, a study of non-resident owners was carried out indicating the mutual relations between the surface area and structure of land in terms of possible practical applications of the land exchange process.

2.1. Fragmentation of Plots

In order to reflect the actual fragmentation of plots of private land in the study area, they were classified into eight groups according to the surface area. The analysis covered the fragmentation of agricultural real property and plots of private owners only. Surveys were carried out in eight size ranges since the average area of the plot does not reflect the adequate fragmentation in respective villages. The following surface areas were selected for analyses: Plots up to 0.10 ha, plots from 0.11 up to 0.30; 0.31–0.60 ha; 0.61–0.90 ha; 0.91–1.20 ha; 1.21–1.50 ha; 1.51–1.80 ha; and above 1.81 ha. A scrupulous analysis of the index of plots for each village was necessary for surveys presenting the fragmentation of private land. Based on this index, plots with a surface area falling within a respective size range were sought. From the point of view of agricultural production organization, the fragmentation of plots has a negative effect on the resulting income. The amount of income and, at the same time, the profitability of production is determined by the size but also shape and elongation of the plot. Theoretically, the number of plots per farm depends on the surface area of the farm, structure of agricultural land, soil quality classes, and natural terrain conditions.

Specific surveys revealed that in the surveyed commune (Figure 2), the largest number of plots fell within the range of 0.11–0.30 ha, accounting for as much as 34.0% of the number of private plots in the commune. The number of plots falling within this range is the lowest, i.e., accounts for 19.6%, in the villages of Nadrybie Wieś and Nadrybie Ukazowe.

One of the reasons behind the smallest fragmentation is that the consolidation of land in those villages took place before 1982. The highest share of plots in the size range 0.11–0.30 ha was noted in Szpica, where the plots account for 40.0%. This village, apart from having a highly fragmented land, has a very unfavourable arrangement of plots, most of which are excessively elongated, which has a negative effect on the organization of the farm's space and its economic performance. The lowest level is the size range of up to 0.10 ha, comprising 3537 plots, which accounts for 23.0% of their total number. The largest share was noted in the village of Puchaczów, being the seat of the commune, characterized by the dense building development, which results in the presence of multiple small building plots. The lowest share in this size range, i.e., 5.5%, was recorded in the village of Nadrybie Dwór. The next size range being 0.31–0.60 ha included 3080 plots, which accounts for 20.2% of their total surface area. From this range until the range 1.51–1.80, the share of the number of plots is observed to decrease along with the increase in the size range. In the last range, the share of the number of plots increases to 3.3%. The largest number of plots in this range is found in the consolidated village Nadrybie Dwór (59 plots), which accounts for 23.1% of their total number in the village. The fragmentation of plots and the scattering of land is a significant problem that reduces the quality of work and life of people running farms. The studies carried out so far show that the result of excessive fragmentation is a higher cost of commuting to the field and lower income from cultivation. The exchange of land results in more rational land management and thus more effective cultivation. The Common Agricultural Policy (CAP) conducted by the European Union is focused on increasing the efficiency of agricultural production and technical progress, ensuring financial security for farmers, stabilizing the agricultural market and people living in rural areas with an appropriate level of income and living conditions. According to the European Commission, economic disparities between the current Member States, despite strong tendencies towards convergence, still persist.

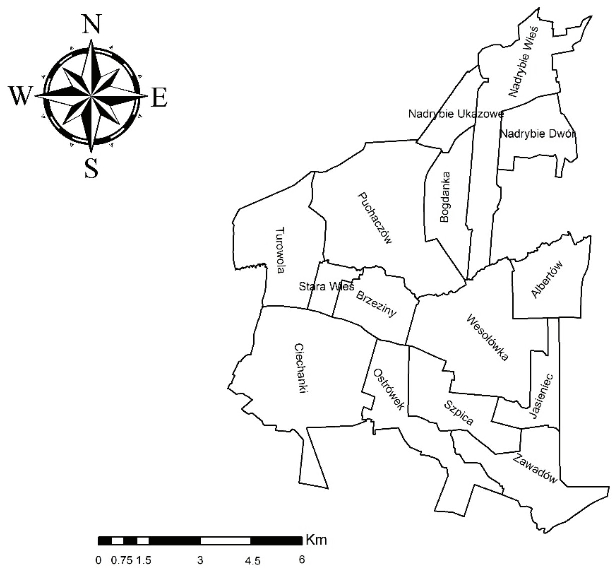

Figure 2. Spatial location of the Puchaczów commune.

2.2. Scattering of Private Plots

As the surveys show, in spite of the land consolidation works taking place in the commune of Puchaczów, the external plot patchwork was not eliminated. Detailed analyses showed that in the analyzed commune there are 3055 out-of-village non-resident owners, which accounts for 55.7% of the total number of private owners. In respective villages, the share of land of out-of-village non-resident owners is differentiated. The number of local non-resident owners from the commune of Puchaczów is also significant, as there are 1583 of them, which accounts for 28.9% of the number of private owners in that commune. A village with the largest number of non-resident owners is Wesołówka. Detailed surveys showed that 50.7% of private owners in that village come from other villages of the commune of Puchaczów. At the same time, the village is characterized by a very low share of the number of local non-resident owners (4.5%). In all the villages of the analyzed commune, the share of land of out-of-village non-resident owners from the study area remains at a fixed level. Only Wesołówka, as mentioned before, has a high share of land of out-of-village non-resident owners.

The spatial distribution of land of non-resident owners, using the example of the villages of Brzeziny and Turowola, is illustrated in Figures 3 and 4. The spatial distribution of land of out-of-village non-resident owners indicates that the plots are scattered throughout the territory of the commune. The intensity with which they occur is evidence of a strong presence of owners from the town of Łęczna and the city of Lublin and those living in adjoining villages. At present, the phenomenon referred to as "spilling" of the city, or suburbanization, is more and more common. Surveys carried out in this area showed that most often these are professionally active people who move to the villages, which increases the share of people of productive age in rural areas [35]. The resettlement of city residents in rural areas is both a disadvantage and an advantage. On the one hand, it can be demonstrated that new residents generate income for the commune from local taxes, contribute to the development of enterprise and rural economy or even the cultural development of the residents of villages. On the other hand, such uncontrolled suburbanization causes disturbance to spatial order [36]. The continuous development of suburban zones gives rise to the need of transforming agricultural land into building grounds but the resources of land are limited.

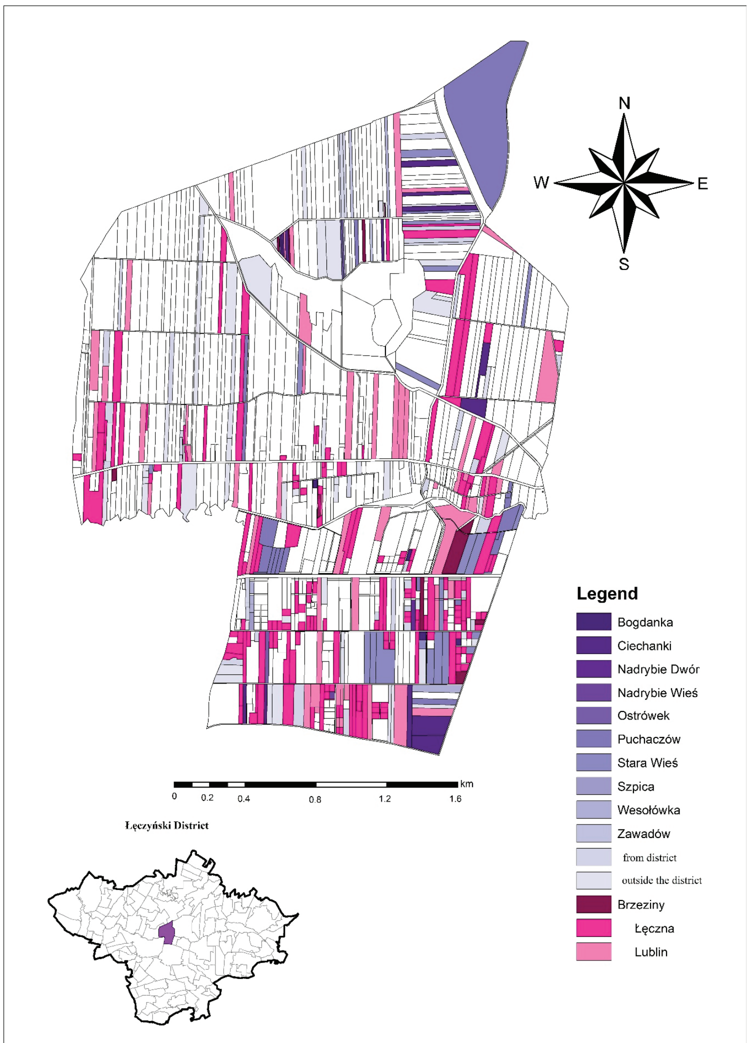

Figure 3. A study of out-of-village non-resident owners in the village of Turowola.

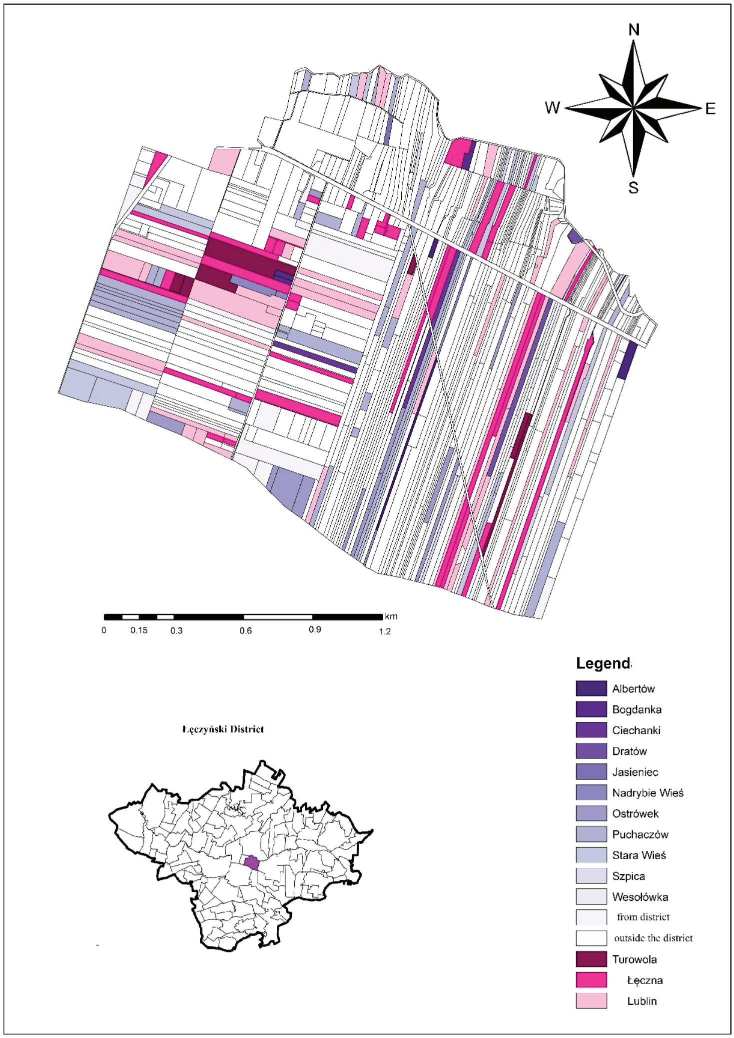

Figure 4. A study of out-of-village non-resident owners in the village of Brzeziny.

The spatial image of the structure of distribution of plots was developed using GIS tools. A significant phenomenon is the occurrence of land of out-of-village non-resident owners from the town of Łęczna and the city of Lublin, which points to a strong impact of these localities on the villages in the commune of Puchaczów. In the surveyed villages, there are 775 owners from the town of Łęczna and 385 from the city of Lublin. Their highest number is observed in the village of Turowola—owners from Łęczna account for 29.2% (155 people) and in the village of Stara Wieś owners from Lublin have a 12.4% share (18 people). The share of the residents of Łęczna and Lublin in the private land of the commune is due to the fact that these people are employed and live in the city and at the same time own building plots in the rural area or inherited the land from their parents. Recently, Turowola has been a village in which a great number of people decided to build their residential properties. Nowadays, the increase in income and transport mobility of city residents gives them the choice of living either in the city or in the country. A growing number of people make use of building plots situated in the villages in city suburbs.

Moreover, building houses in the suburbs make the city less crowded and generate its uncontrolled development [37].

Detailed data concerning the distribution of land of non-resident owners are presented in Table 1. The data show that the number of villages from which non-resident owners living in the county of Łęczna come from is from eight in Nadrybie Wieś to 29 in Wesołówka. Non-resident owners from more than 22 villages of the county have their plots in nine villages from the commune of Puchaczów. The number of non-resident owners who come from outside the study area and from the town of Łęczna and the city of Lublin is also significant. Their share ranges from 37% in Brzeziny to 69.4% in Puchaczów.

Table 1. Structure of distribution of land of non-resident owners in the study area.

No.	Village	Overall Number of Villages from Which Non-Resident Owners of Plots Come from	Number of Villages from Which Local Non-Resident Owners of Plots (from the County) Come from		Number of Localities Outside the Study Area, Including the Town of Łęczna and the City of Lublin	
			Number of	%	Number of	%
1	Nadrybie Wieś *	55	25	45.5	30	54.5
2	Brzeziny	27	17	63.0	10	37.0
3	Nadrybie Ukazowe *	19	8	42.1	11	57.9
4	Stara Wieś	19	9	47.4	10	52.6
5	Albertów *	41	25	61.0	16	39.0
6	Bogdanka *	15	7	46.7	8	53.3
7	Ciechanki	64	28	43.8	36	56.3
8	Jasieniec	27	14	51.9	13	48.1
9	Nadrybie Dwór *	33	11	33.3	22	66.7
10	Ostrówek	50	24	48.0	26	52.0
11	Puchaczów *	72	22	30.6	50	69.4
12	Szpica	39	23	59.0	16	41.0
13	Turowola **	60	25	41.7	35	58.3
14	Wesołówka	49	29	59.2	20	40.8
15	Zawadów	48	22	45.8	26	54.2

* Villages consolidated before 1982. ** Villages consolidated after 1982. Source: Own elaboration.

The surveys regarding the distribution of land of non-resident owners in the study area demonstrate that many people living outside the analyzed county own plots of land in that county. Table 1 does not show end totals, since localities from which non-resident owners come from recur in respective villages. If they were summed up, the result would be incorrect. The external plot patchwork (non-resident owners) in the villages of the analyzed commune, as indicated by the surveys, is a result of the rules of inheritance, dividing large estates into parcels and migration of people from rural areas to urban and industrial centers. The studies concerning the external plot patchwork show that plots of land of out-of-village and local non-resident owners in the villages of the commune of Puchaczów differ in size. Depending on the strength of impact between the villages, a higher or lower number of plots, the owners and area owned by non-resident owners is observed. Previous practice reveals that in a specific village there is no land of non-resident owners from all the surveyed villages. The external plot patchwork is surveyed using the chequerboard array method making it possible to separate the plots of land of local non-resident owners from those of out-of-village non-resident owners [38]. Due to the use of chequerboard arrays in the analysis and evaluation of the plot patchwork a matrix may be created at any level including one village, more than one village, a commune or more than one commune, depending on the level of detail we want to obtain [38]. The deficiency of land from respective villages is marked with an "x". Next, the matrix was ordered so that the biggest share of land of non-resident owners was arranged along the diagonal. Such an ordered matrix makes it possible to determine the relationship between villages and also for the whole analyzed area. Based on previous experience, it should be stated that using the above-described method in the treatment and balancing of the plot patchwork, it can be determined in a simple and clear manner how intense the scattering of private plots is. Patterns of plot patchwork occurring between villages make it possible to develop a plot patchwork elimination programme. Based on detailed analyses a land exchange proposal was prepared.

2.3. Possibility of Elimination of External Plot Patchworks

Private land situated out of the dwelling place of its owners constitutes the external plot patchwork. The use of chequerboard arrays in analyzing and evaluating the presence of local and out-of-village non-resident owners provides a possibility of creating a matrix at any level- for a village, commune, county, and voivodeship. The level depends on the range of occurrence of the plot patchwork. The only drawback of this method can be when a matrix is being developed for multiple elements of the spatial structure of land to be analyzed (number of plots, items in the register, occupied surface area, plots of agricultural land, or soil quality classes).

However, the uniformity of matrices facilitates detailed analyses and assessments of such thematically uniform matrices to the extent of the mutual impact of villages and towns/cities covered by the matrix. It makes it possible to determine when the impact of a specific locality on another one is a result of the function it performs in the socio-economic, cultural, and administrative system of the specific area. Plot patchworks inside the village are analyzed similarly to the external plot patchworks [39]. The external plot patchwork is a complex issue characterized by spatial distribution due to the dwelling places of landowners. The scattering of land in the agricultural space shows some patterns connected to the impact of cultural and religious centers, industrial centers, cities being the seat of counties and voivodeships on rural areas. The further the village is from such centers, the number and surface area of plots of land covered by the external plot patchwork decreases. The occurrence of external plot patchwork is a complex issue due to the fact that the land is either owned by local or out-of-village non-resident owners, which is illustrated in Figure 5.

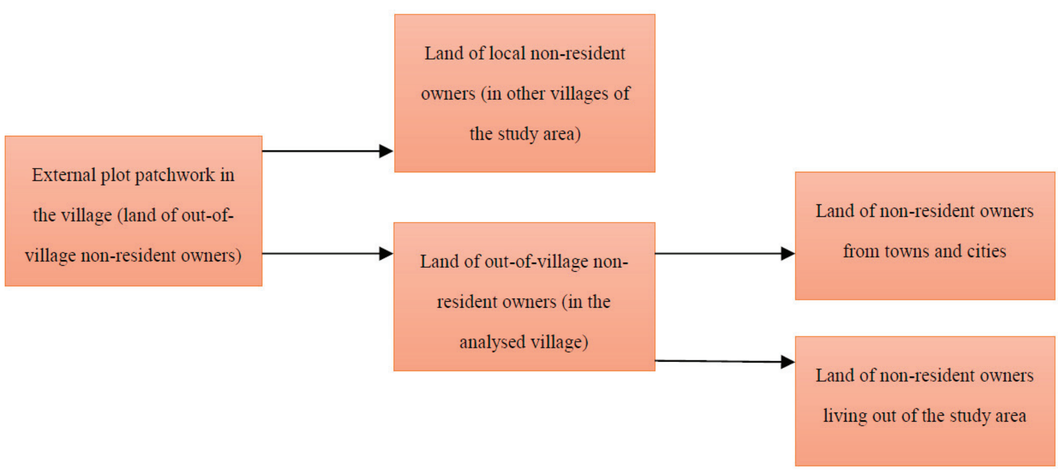

Figure 5. Division of land forming the external plot patchwork.

The occurrence of external plot patchwork is not limited by the administrative boundaries of communes. This situation is a result of marriages or migration to urban and industrial centers by people seeking jobs. The survey regarding the occurrence of land of non-resident owners and the review of reference literature shows some patterns in the concentration and location of non-resident owners around administrative and service centers (seat of the commune authorities), religious centers, and adjoining villages. A characteristic feature is adjoining villages with mutual relationships between the surface area of land owned (local and out-of-village non-resident owners). The status of occurrence of plots of land of non-resident owners observed in the study area makes it possible to exchange them, e.g., between these villages. The surface area of land of local and out-of-village non-resident owners in the villages of the surveyed commune testifies to the possibility of land exchange. Such an exchange before the consolidation of land makes it possible to eliminate the external plot patchwork. Such an exchange of land, as shown by the surveys, will not only decrease the length of access to plots but at the same time in the consolidation process the households of the owner will increase by the area previously owned outside the boundaries of the village.

Figure 6 presents the proposed land exchange algorithm. This simple configuration can be presented as follows:

$$A - B - C = X \quad (1)$$

$$X - D + I = Y \quad (2)$$

$$Y + B + C = Z \quad (3)$$

where:

A—surface area of private land in the commune;

B—surface area of out-of-village non-resident owners living in towns and cities;

C—surface area of land of out-of-village non-resident owners living outside the analyzed county;

D—surface area of land of out-of-village non-resident owners living in the county;

I—surface area of land of local non-resident owners living in the county;

Z—surface area of private land after the exchange.

In the case of a lack of land in the village, the land of the State Treasury can be used and exchanged. It is proposed to include the land of non-resident owners not living in the county and living in towns and cities in the consolidation works but on the condition that they are leased to local farmers.

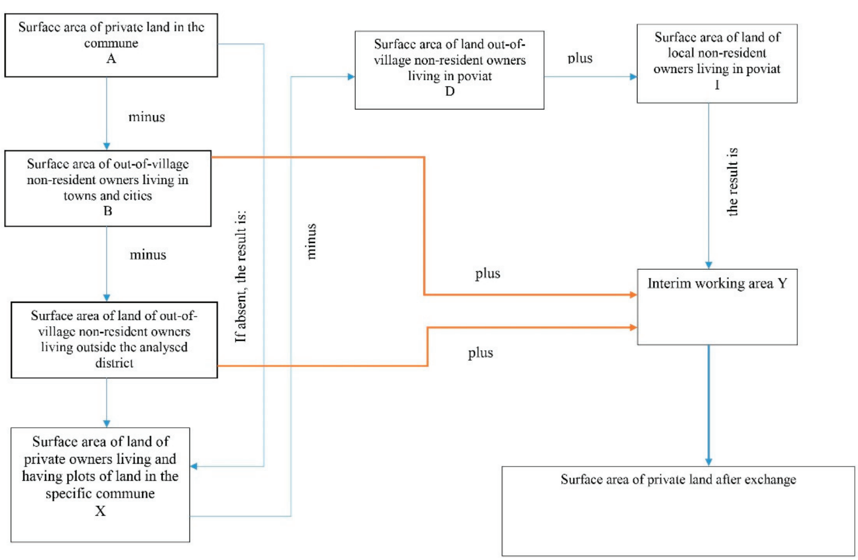

Figure 6. Land exchange algorithm.

The operation presented in the algorithm was used for calculating the exchange between out-of-village and local non-resident owners for the area of the county and the commune, which is presented further in the publication.

3. Results and Discussion

The Use of the Algorithm in the Area of the Commune of Puchaczów

As demonstrated by Table 2, changes in the area of respective communes are not significant. The biggest change as a result of the exchange of land of non-resident owners can be observed in the commune of Puchaczów, i.e., 172.09 ha, which accounts for 1.9% of the area of this commune. In the communes of Łęczna and Milejów, as a result of the required exchange, the change in surface area would be respectively 79.25 and −159.14 ha, which for both communes corresponds to only 1.4% of their total area. The surface area of the commune of Cyców should decrease by 76.62 ha, which accounts for 0.5% of the total surface area of the commune. The smallest changes should take place in the communes of Ludwin −46.73 ha (0.4%) and Spiczyn 31.14 ha (0.4%).

Table 2. Proposed exchange of land in the county.

No.	Name of Commune	Number of Villages in the Commune	Surface Area of Private Land in the Commune [ha]	Expected Surface Area of Private Land in the Commune after Exchange	Change in the Surface Area of Private Land		Expected Surface Area of the Commune after Exchange	Change in the Surface Area of the Commune	
				ha	ha	%	ha	ha	%
1	Cyców	29	12,302.65	12,226.03	−76.62	−0.6	14,724.18	−76.62	−0.5
2	Ludwin	21	9278.37	9231.64	−46.73	−0.5	12,159.33	−46.73	−0.4
3	Łęczna	15	4845.74	4924.99	79.25	1.6	5694.17	79.25	1.4
4	Milejów	24	9591.63	9432.49	−159.14	−1.7	11,488.26	−159.14	−1.4
5	Puchaczów	15	6907.80	7079.89	172.09	2.5	9330.06	172.09	1.9
6	Spiczyn	12	6636.46	6667.60	31.14	0.5	8341.38	31.14	0.4
	Total	116	49,562.65	49,562.65	0.00	0.0	61,737.38	0.00	0.0

Source: Own elaboration.

Table 3 presents the applications of the algorithm to land exchange within the commune of Puchaczów. Considering the commune as a whole, both the surface area of private land and the surface area of the whole commune will not change considerably. The area of private land in the commune, after the exchange of land of non-resident owners between respective villages, will increase by 172.09 ha, which for the surface area of private land corresponds to 2.5%, and for the surface area of the commune to 1.9%. However, differences occur in respective villages. The biggest change in the percentage share was recorded in Stara Wieś 2. Due to the exchange, the surface area of the village will increase by 81.74 ha, which corresponds to as much as 61.6% of the overall surface area of this village. In terms of surface area, the biggest change will occur in Wesołówka, where the area of the village will be reduced by 368.20 ha, which accounts for 35.2% of the total surface area of this village. Another village subject to significant changes is Ostrówek the surface area of which after the exchange will be 163.64 ha, which accounts for 27% of its total surface area. Other changes in the surface area decrease to 11.21 ha in Turowola, which accounts for 1.6% of the total surface area of the village. Of course, considering the land owned by, for example, non-resident owners living in cities or outside the county, the changes would be greater, but such non-resident owners cannot be made to exchange their plots. It is proposed that the land owned by them was first leased, especially if this is agricultural land. However, very often non-resident owners living in cities have small building plots inherited from their parents or bought for leisure and building purposes [2,3,5].

In technical and legal terms, the exchange of land is feasible. However, in order to ensure that it can be performed prior to or in the course of consolidation of land, we are required to obtain the consent of non-resident owners to proceed with land exchange. The proposed exchange of land between the owners will bring the land closer to the farmer's place of residence. This will have a significant impact on the decrease in financial outlays for access to the field. The occurrence of external plot patchwork is not limited by the administrative boundaries of communes, which is demonstrated by specific surveys carried out in the commune of Puchaczów, presented in Table 3. This situation is a result of marriages or migration to urban and industrial centers by people seeking jobs. The survey regarding the occurrence of land of non-resident owners and the review of reference literature shows some patterns in the concentration and location of non-resident owners around administrative and service centers (seat of the commune authorities), religious centers, and adjoining villages. A characteristic feature is adjoining villages with mutual relationships between the surface area of land owned (local and out-of-village non-resident owners).

Table 3. Proposed exchange of land in the commune.

No.	Village	Surface Area of Private Land in the Village [ha]	Expected Surface Area of Private Land in the Village after Exchange	Change in the Surface area of Private Land		Expected Surface area of the Village after Exchange	Change in the Surface Area of the Village	
			ha	ha	%	ha	ha	%
1	Albertów	417.44	473.07	55.64	13.3	506.58	55.64	12.3
2	Bogdanka	301.13	285.11	−16.02	−5.3	518.33	−16.02	−3.0
3	Brzeziny	364.35	475.19	110.84	30.4	486.08	110.84	29.5
4	Ciechanki	914.02	882.54	−31.48	−3.4	1244.00	−31.48	−2.5
5	Jasieniec	273.96	267.60	−6.36	−2.3	292.07	−6.36	−2.1
6	Nadrybie Dwór	319.96	335.58	15.61	4.9	381.85	15.61	4.3
7	Nadrybie Ukazowe	206.33	280.66	74.33	36.0	295.70	74.33	33.6
8	Nadrybie Wieś	561.69	520.57	−41.13	−7.3	838.62	−41.13	−4.7
9	Ostrówek	572.12	735.76	163.64	28.6	769.97	163.64	27.0
10	Puchaczów	556.16	601.40	45.23	8.1	1216.56	45.23	3.9
11	Stara Wieś 2	122.82	204.57	81.74	66.6	214.37	81.74	61.6
12	Szpica	444.21	505.87	61.66	13.9	537.02	61.66	13.0
13	Turowola	621.90	633.12	11.21	1.8	728.93	11.21	1,6
14	Wesołówka	740.92	372.73	−368.20	−49.7	678.19	−368.20	−35.2
15	Zawadów	490.77	506.13	15.36	3.1	621.78	15.36	2.5
	Total:	6907.80	7079.89	172.09	2.5	9330.06	172.09	1.9

Source: Own elaboration.

These mutual relationships between the surface area of land owned by owners living in respective villages are presented in detail in a matrix including all villages in the analyzed county and in a matrix prepared for the commune of Puchaczów. The matrices constitute a fundamental database allowing the exchange of land between villages. A visual specification of the possibilities of proceeding with the exchange is the graphic illustration of the occurrence of land of local and out-of-village non-resident owners informing on the possibility of proceeding with the exchange between villages in the surveyed commune. On the other hand, the study of out-of-village non-resident owners contains detailed information about the spatial distribution of plots, which is illustrated in Figures 3 and 4. In the previous consolidation works, such a study was prepared for the village being consolidated but land exchange was not carried out. Such a study was only a formal, redundant appendix, since no interest was taken in the land owned by the participants of consolidation if such land was not situated in their dwelling place. Therefore, all the consolidation works in the study area are characterized by a high share of land of out-of-village non-resident owners and residents of the consolidated villages still own land in other villages. In connection with this fact, land consolidation should be preceded by land exchange. To this end, the presence of land of non-resident owners must be analyzed using chequerboard arrays which will facilitate preparing the matrices. This will allow us to differentiate between the land of local non-resident owners and that of out-of-village non-resident owners.

The spatial illustration of a plot occurring in both villages, presented in Figure 3 for Turowola and in Figure 4 for Brzeziny, at the same time shows the land of out-of-village non-resident owners included in the legend. The land is simultaneously owned by out-of-village non-resident owners in one village and by local non-resident owners in the other village. The status of occurrence of plots of land of non-resident owners observed makes it possible to exchange them, e.g., between these villages. To sum up, the external plot patchwork, as demonstrated by the surveys concerning its spatial distribution, may be eliminated by the exchange, lease, and sale of land. The operation presented in the algorithm was used for calculating the exchange between the out-of-village and local non-resident owners for the area of the county and the commune, which is presented in Tables 2 and 3.

4. Conclusions

The proposed land exchange algorithm, not only in the process of consolidation works, should be propagated among farmers as it provides a possibility of bringing the land closer to the owner's dwelling and designing larger surface areas of the registered plots. The algorithm was tested in the area of the Puchaczów commune in 15 villages. Detailed studies have shown that both the area of individual lands and the area of the entire commune will not change significantly. The area of individual land in the commune, after the exchange of land between individual villages, will increase by 172.09 ha, which is 2.5% for the area of individual lands and 1.9% for the area of the commune. On the other hand, differentiation occurs in individual villages. To sum up, the external plot patchwork, as demonstrated by the surveys concerning its spatial distribution, may be eliminated by the exchange, lease, and sale of land.

Until now, similar algorithms have not been used for the exchange of land. It is advisable to conduct further research, which will take into account such aspects as soil class, slope, road access, or land value. The designed algorithm can be used in other areas, which was confirmed by the analyses. However, research should be expanded. Surveys can be carried out to see if farmers are interested in the exchange of land. Additionally, it is advisable to check in which areas the land exchange should be carried out in the first place. Due to its complexity, this procedure cannot be performed in the entire area at the same time.

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References

1. Latruffe, L.; Piet, L. Does land fragmentation affect farm performance? A case study from Brittany, France. *Agric. Syst.* **2014**, *129*, 68–80. [CrossRef]
2. Noga, K.; Król, Ż. The Patchwork of Land as a Problem Restricting the Development of Rural Areas. *Barom. Reg. Anal. I Progn.* **2016**, *14*, 165–173.
3. Król, Ż.; Leń, P. Indyvidual plot patchwork determination of the urgency in realization consolidation and exchange of land. *Infrastruct. Ecol. Rural Areas* **2016**, *No II/1/2016*, 311–322.
4. Kwinta, A.; Gniadek, J. The description of parcel geometry and its application in terms of land consolidation planning. *Comput. Electron. Agric.* **2017**, *136*, 117–124. [CrossRef]
5. Leń, P. An algorithm for selecting groups of factors for priorization of land consolidation in rural areas. *Comput. Electron. Agric.* **2018**, *144*, 216–221. [CrossRef]
6. Wójcik-Leń, J.; Sobolewska-Mikulska, K.; Sajnóg, N.; Leń, P. The idea of rational management of problematic agricultural areas in the course of land consolidation. *Land Use Policy* **2018**, *78*, 36–45. [CrossRef]
7. Stręk, Ż.; Noga, K. Method of delimiting the spatial structure of villages for the purposes of land consolidation and exchange. *Remote Sens.* **2019**, *11*, 1268. [CrossRef]
8. Postek, P.; Leń, P.; Stręk, Ż. The proposed indicator of fragmentation of agricultural land. *Ecol. Ind.* **2019**, *103*, 581–588. [CrossRef]

9. Basista, I.; Balawejder, M. Assessment of selected land consolidation in south-eastern Poland. *Land Use Policy* **2020**, *99*, 105033. [CrossRef]
10. Janus, J.; Ertunc, E. The impact of differences in land fragmentation parameters on the planning, implementation, and evaluation of land consolidation projects. Case studies of Turkey and Poland. *Comput. Electron. Agric.* **2020**, 179. [CrossRef]
11. Van Dijk, T. Land consolidation as Central Europe's Panacea reassessed. In Proceedings of the Symposium on Modern Land Consolidation, Volvic (Clermont-Ferrand), France, 10–11 September 2004; Available online: http://www.fig.net/commission7/france_2004/papers_symp/ts_01_vandijk.pdf (accessed on 1 October 2020).
12. Demetriou, D. *The Development of an Integrated Planning and Decision Support System (IPDSS) for Land Consolidation*; Springer International Publishing: Cham, Switzerland, 2014.
13. Guo, B.; Jin, X.; Yang, X.; Guan XLin, Y.; Zhou, Y. Determining the effects of land consolidation on the multifunctionlity of the cropland production system in China using a SPA-fuzzy assessment model. *Eur. J. Agron.* **2015**, *63*, 12–26. [CrossRef]
14. Sklenicka, P.; Janovska, V.; Salek, M.; Vlasak, J.; Molnarova, K. The Farmland Rental Paradox: Extremel and ownership fragmentation as a new form of land degradation. *Land Use Policy* **2014**, *38*, 587–593. [CrossRef]
15. Tomić, H.; Mastelić, I.S.; Roić, M. Land consolidation suitability ranking of cadastral municipalities: Information-based decision-making using multi-criteria analyses of official registers' data. *ISPRS Int. J. Geoinf.* **2018**, *7*, 87. [CrossRef]
16. Hudecova, L.; Geisse, R.; Gasincova, S.; Bajtala, M. Quantification of Land Fragmentation in Slovakia. *Geod. List* **2017**, *4*, 327–338.
17. Niroula, G.S.; Thapa, G.B. Impacts and causes of land fragmentation, and lesson learned from land consolidation in South Asia. *Land Use Policy* **2005**, *22*, 358–372. [CrossRef]
18. Colombo, S.; Perujo-Villanueva, M. Inefficiency due to parcel fragmentation in olive orchards. *Acta Hortic* **2018**, *1199*, 159–164. [CrossRef]
19. Manjuantha, A.V.; Anik, A.R.; Speelman, S.; Nuppenau, E.A. Impact of land fragmentation, farm size, land ownership and crop diversity on profit and efficiency of irrigated farms in India. *Land Use Policy* **2013**, *31*, 397–405. [CrossRef]
20. Knippenberg, E.; Jolliffe, D.; Hoddinott, J. *Land Fragmentation and Food Insecurity in Ethiopia*; Policy Research Working Paper 2018; World Bank Group: Washington, DC, USA, 2018; Available online: https://openknowledge.worldbank.org/bitstream/handle/10986/30286/WPS8559.pdf?sequence=1 (accessed on 1 October 2020).
21. Jin, X.; Shao, Y.; Zhang, Z.; Resler, L.M.; Campbell, J.B.; Chen, G.; Zhou, Y. The evaluation of land consolidation policy in improving agricultural productivity in China. *Sci. Rep.* **2017**, *7*, 1–9. [CrossRef]
22. Munnangi, A.K.; Lohani, B.; Misra, S.C. A review of land consolidation in the state of Uttar Pradesh, India: Qualitative approach. *Land Use Policy* **2020**, *90*, 104309. [CrossRef]
23. Noga, K. *Analysis of the Intervillage Plot Patchwork on the Example of Villages Situated in the Upstream Catchment of the River Soła*; Scien. Sess. 7. Issue 7. Scien. Booklets No. 133; University of Agriculture: Kraków, Poland, 1977; pp. 154–170.
24. Rabczuk, I. The problem of non-resident owners in the poviat of Proszowice, Kraków voivodeship. In *Current Issues in Rural Management Surveying*; SGP: Warsaw, Poland, 1968; pp. 65–70.
25. Bentley, J.W. Economic and ecological approaches to land fragmentation: In defense of a much-maligned phenomenon. *Annu. Rev. Anthropol.* **1987**, *16*, 31–67. [CrossRef]
26. Stańczuk-Gałwiaczek, M.; Sobolewska-Mikulska, K.; Ritzema, H.; van Loon-Steensma Jantsje, M. Integration of water management and land consolidation in rural areas to adapt to climate change: Experiences from Poland and the Netherlands. *Land Use Policy* **2018**, *77*, 498–511. [CrossRef]
27. Muchová, Z.; Jusková, K. Stakeholders' perception of defragmentation of new plots in a land consolidation project: Given the surprisingly different Slovak and Czech approaches. *Land Use Policy* **2017**, *66*, 356–363. [CrossRef]
28. Xiao, W.; Mills, J.; Guidi, G.; Rodrigez-Gonzalvez, P.; Gonizzi Barsanti, S.; Gonzalez-Aguilera, D. Geoinformatics for the conservation and promotion of cultural heritage in support of the UN Sustainable Development Goals. *ISPRS J. Photogramm. Remote Sens.* **2018**, *142*, 389–406. [CrossRef]
29. Hiironen, J.; Riekkinen, K. Agricultural impacts and profitability of land consolidations. *Land Use Policy* **2016**, *55*, 309–317. [CrossRef]
30. Asiama, K.; Bennett, R.; Zevenbergen, J. Land consolidation for Sub-Saharan Africa's customary lands: The need for responsible approaches. *Am. J. Rural Dev.* **2017**, *5*, 39–45. [CrossRef]
31. Gedefaw, A.A.; Atzberger, C.; Seher, W.; Mansberger, R. Farmers Willingness to Participate In Voluntary Land Consolidation in Gozamin District, Ethiopia. *Land* **2019**, *8*, 148. [CrossRef]
32. Yaslioglu, E.; Akkaya Aslan, S.T.; Kirmikil, M.; Gundogdu, K.S.; Arici, I. Changes in Farm Management and Agricultural Activities and Their Effect on Farmers' Satisfaction from Land Consolidation: The Case of Bursa–Karacabey, Turkey. *Eur. Plan. Stud.* **2009**, *17*, 327–340. [CrossRef]
33. Act of 24 January, 1968. Act on Land Consolidation and Exchange (Journal of Laws 1968, No. 3, Item 13). Available online: http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU19680030013/O/D19680013.pdf (accessed on 30 October 2020).
34. Act of 26 March, 1982. Act on Land Consolidation and Exchange (consolidated Text, Journal of Laws 2019, Item 861). Available online: http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU19820110080/U/D19820080Lj.pdf (accessed on 30 October 2020).
35. Źróbek-Różańska, A.; Zysk, E. Real estate as a subject of spatial conflict among central and local authorities. *Real Estate Manag. Valuat.* **2015**, *23*, 88–98. [CrossRef]

36. Źróbek-Różańska, A.; Źróbek, S.; Źróbek, R. Urban Sprawl and the Problems of Changes of Land Use on the Fringe Areas of Towns. In Proceedings of the International Conference on Environmental Engineering, Vilnius, Lithuania, 22–23 May 2014.
37. Chen, G.; Hadjikakou, M.; Wiedmann, T.; Shi, L. Global warming impact of suburbanization: The case of Sydney. *J. Clean. Prod.* **2018**, *172*, 287–301. [CrossRef]
38. Noga, K. *Topology of Mountain Villages for the Needs of Rural Management Works. Land Surveying*; Scientific Papers No. 155; University of Agriculture: Kraków, Poland, 1979; Volume 6, pp. 17–29.
39. Noga, K. *Methodology of Programming and Implementation of Consolidation and Exchange of Land Works in the Complex Formulation*; Szkoła wiedzy o Terenie: Kraków, Poland, 2001.

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Review

Geographic Information Systems and the Sustainable Development of Rural Areas

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Abstract: Sustainable development is socioeconomic growth that integrates political, economic, and social measures alongside environmental protection to meet the needs of communities and citizens without compromising the ability of future generations to meet their needs. The sustainable development concept was initially based on three main pillars: environment, economy, and society. In successive years, this concept has been expanded to include new pillars. The awareness of these changes has influenced our research interests. The main research objective of this study was to evaluate the applicability of geographic information system (GIS) tools (data, tools, and multidimensional analyses) to the implementation of sustainable development principles in rural areas. The study covered rural and nonurbanized areas in Poland, especially farmland, forests, fisheries, and farms. The study presents the results of our research into environmental, economic, and social determinants of growth in the spatial dimension. GIS tools continue to evolve, which improves access to information and increases database managers' awareness that highly accurate data are needed for spatial analyses. GIS systems allow us to formulate, in a structured and formal way, models that reflect both the current state and forecast changes that will occur in space. It is a very useful tool in the sustainable development of rural areas.

Keywords: rural areas; sustainability; geographic information systems; data sources; determinants of development

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1. Introduction

Pollution is a problem that surfaced in the 19th century, mainly in industrial and heavily populated areas, but was recognized as a serious threat to human well-being only in the 1960s [1]. The sustainable development concept, which originated in the 1970s, postulated that environmental protection should be taken into account in social and economic development. This notion undermined the existing definition of economic growth. The term "sustainable development" came into use in policy circles after the publication of the Brundtland Commission's report on the global environment and development in 1987 [2]. The Brundtland Commission defined sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [2,3]. The report also marked the first use of the term "sustainable development." In Poland, the principles of ecologically sustainable development were formulated only in the late 1990s. In 1991, the Polish parliament adopted a resolution on environmentally friendly policy that amended the Act on Environmental Protection and Management of 31 January 1980 (Journal of Laws, 1994, No. 49, item 196) [4]. The Environmental Protection Law defines sustainable development as socioeconomic growth that integrates political, economic, and social measures with environmental protections to meet the current needs of communities and citizens without compromising the ability of future generations to meet their needs [5]. The resolution states that Poland is guided by the principles of sustainable development, and the relevant provisions have been incorporated in the Constitution of the Republic of Poland in 1997 (Art. 5) [6]. The constitution places all institutions under the obligation to protect the environment and to guarantee the ecological security of present and future generations. Ecological considerations are the cornerstone of sustainable development in theory and in practice. Sustainable development has many different meanings and therefore provokes many different responses. Based on Hopwood et al. [7], the concept of sustainable development is an attempt to combine growing concerns about a range of environmental issues with socioeconomic aspects.

In the literature we can find analyses of sustainable development from various points of view: in agriculture [8–11], urbanization [12–14], sustainable cities [15,16], sustainable tourism [17,18], the social dimension [19–22], ecological economics [23,24] and more. In 2016, Polish scientists presented select definitions of sustainable development in chronological terms. They presented 38 different attempts to define sustainable development [25]. A universal approach to the implementation of sustainability strategies has never been proposed because space is a highly diverse phenomenon that requires a multidisciplinary, multidirectional, and multicriteria approach.

The sustainable development concept was initially based on three main pillars: the environment, economy, and society. In successive years, this concept has been expanded to include new pillars. These changes have influenced our research interests. In Poland, in a 2011 report [26], the Central Statistical Office published 76 indicators of sustainable development. In a 2015 report [27], the number of indicators was expanded to 101, and the institutional and political domain was included as the fourth pillar of sustainable development. In many cases, the institutional domain is regarded as a barrier to development or as an institutional gap [28–30]. We have also addressed the problems relating to the institutional domain in rural areas in studies dedicated to the development of renewable energy sources in Poland [31,32] and the absorption of EU funds in rural areas [33,34]. The search for new indicators of sustainable development has inspired us to analyze the influence of the Common Agricultural Policy (CAP) on the sustainable development of rural areas [35–37]. Sustainability indicators in various areas of social and economic life facilitate analyses of progress in the implementation of sustainable development policies [38]. Mitchell emphasized that "existing indicator sets are not obviously compatible and there is a danger that, without the application of a clear method, indicators will be produced in an ad hoc fashion without full consideration of key sustainable development principles or indicator characteristics" [39], (pp. 1). Tasaki et al. [40] surveyed a total of 1790 indicators and classified them into 77 subcategories and four categories. The indicators measured various elements. The indicators captured to each country's developmental stage and specific conditions. These indicators are used to denote the limits of human activities in relation to the natural environment, to estimate the extent to which human needs can be satisfied by existing natural resources, and to determine the permanence of the three pillars of sustainability. The relevant indicators are developed by measuring the constituent elements of eco-development: balanced development, permanent growth, and self-sustained development [41]. Spatial order, the fifth pillar of sustainable development, has only recently been incorporated into Polish legislation. Spatial order is evaluated in land management analyses and plays an important role in local development [42–44]; it is an object of scientific inquiry in geodesy and cartography. The significance of the green economy concept, which, until recently, had been limited to the domain of economic sciences, was recognized in Poland around 2008. The green economy aims to reduce the consumption of energy derived from fossil fuels, to maximize the efficiency of energy generation and energy resources, and to increase the share of renewable energy in the overall energy balance [45–47]. On 1 January 2016, the 17 Sustainable Development Goals of the 2030 Agenda for Sustainable Development came into force [48]. Sustainable development is one of the concepts of the modern theory of global economy development and represents a response to the necessity of preventing environmental degradation. Sustainable development is a result of adopting the principle of integrated order, perceived as a coherent and simultaneous perception of the economic, social, and natural order [8].

New pillars of sustainable development are likely to emerge as continued economic growth and globalization contribute to environmental degradation. The question that remains to be answered is whether the search for new pillars of sustainability makes a real contribution to analyses of initiatives that support sustainable development.

There is currently no generally accepted definition of "rural areas" [49–51], and there is no consensus on how to construct a consistent definition [52,53]. According to statistical institutions, rural areas are defined as territories situated outside the administrative boundaries of urban areas. In some cases, rural areas are classified based on their population or population density. Rural areas play a very important role in social life and the economy. Rural areas are places of residence and employment, but they are also recreational sites that enable visitors to enjoy unspoiled nature. Rural areas are suppliers of raw materials and products, but they are mainly providers of space for other functions. Recently, with the industrialization and expansion of urban areas, we can observe a decrease in both land and the workforce. Additionally, farmers have felt the need to adapt by diversifying production and increasing corporate income by introducing other complementary activities. From this point of view, we can say that "multifunctional agriculture" covers all the functions ascribed to agriculture: from the environmental to the sociocultural, and from tourist services to educational and cultural services [54]. For these reasons, rural space should be managed effectively, in line with the principles of sustainable development.

Geographic information system (GIS) is a highly useful tool in the decision-making process in the domain of physical, social, and economic space. GIS tools support the acquisition of spatial data from various sources, rapid processing of data, and the release of data in the desired form for multidisciplinary analyses, studies, and forecasts [55]. GIS tools are used to collect, gather, edit, process, update, and release spatial data. They are most useful in the process of acquiring input data from various sources with the involvement of different methods and techniques, beginning from crude field data and moving to fully automated data acquisition systems that do not require human involvement. Data from various sources are processed to generate new information and products [56].

The preservation of the delicate balance between spatial order, ecological rationality, social acceptance, and economic profitability is very difficult in land management. This is particularly true in rural areas, where the main goals of development should be focused on spatial, social, economic, and environmental functions. Local communities have to be activated for the above goals to be achieved. The use of advanced GIS tools supports the dissemination of reliable information and increases the awareness of local community members. Integration and universal access to various types of geoinformation, collected and updated by the public administration sector, are implemented as part of the Spatial Information Infrastructure, which is a direct implementation of the INSPIRE Directive [57].

The study presents the results of research into environmental, economic, and social determinants of growth in the spatial dimension in rural areas, closely linked with the concept of sustainable development and the challenges faced by Europe in a globalized economy. The main research objective was to evaluate the applicability of GIS tools (data, tools, and multidimensional analyses) to the implementation of sustainable development principles in rural areas in Poland. Agriculture, forestry, and fisheries are the sectors of the economy in which the most favorable conditions for implementation of the principles of sustainable development exist. On the one hand, the resources of the natural environment are used, and on the other hand, farmers and producers, through their activities, shape the environment [8].

2. Materials and Methods

2.1. Area and Object of Study

The study covered rural and nonurbanized areas in Poland. Rural areas account for around 93% of Poland's territory. Since the definition of rural areas is ambiguous, the area and the object of research were defined in this stage of the study. Agriculture, forestry, and water management are the main segments of the rural economy; therefore, farmland, forests, and fisheries were selected as the areas of research. Pursuant to the provisions of Art. 3e of the Council Regulation (EC) No. 1198/2006, a fishery is "an area with a sea or lake shore or including ponds or a river estuary and with a significant level of employment in the fisheries sector" [58]. The study also focused on farms as the main units of economic activity in rural areas.

2.2. Sources and Scope of Data

Various sources of data were used, including statistical data released into the public domain by the Central Statistical Office (GUS), survey results [59,60], and data acquired from institutions responsible for specific tasks in the investigated areas (e.g., Fisheries Local Action Groups (FLAGs) [35], Agricultural Advisory Center of the Region of Warmia and Mazury in Olsztyn [59,60], and the Regional Directorate for National Roads and Motorways in Olsztyn [61]). The obtained data were used to develop databases at various levels of reference. Databases were subjected to spatial analyses with the use of dedicated computer applications (comparative analyses at the level of municipalities [59], or associations of municipalities: FLAGs [35], regions and counties [36], parcels as a part of agricultural holdings, as well as analyses based on the existing road infrastructure [61]).

Geographic information web portals were also a useful source of data for analysis. Data generated by Web Map Service (WMS) servers were used to create raster layers on the map of the analyzed objects, which supported detailed evaluations. Various types of data were processed with the use of appropriate tools and methods.

Different types of data were used in studies analyzing the potential of renewable energy sources, mainly biomass produced by farms in the Region of Warmia and Mazury. The analyses were carried out based on the results of a survey conducted in 2012 among biomass producers and biomass processing companies in the region. The number of participants was determined based on the data provided by the employees of Agricultural Advisory Center of the Region of Warmia and Mazury in Olsztyn specializing in renewable energy sources [59,60]. The spatial distribution of biomass producers and processing companies was determined by geocoding (based on registered address).

Geographic information systems are composed of software, hardware, data, administrators, and methods for processing and analyzing data [62]. The main functions of GIS are the collection, verification, accumulation, integration, processing, and release of spatial data (information about geographic space). Users can combine descriptive data with information about the spatial location of the analyzed objects; they can generate thematic maps, conduct spatial analyses, and formulate conclusions. These functions are shown in Figure 1.

2.3. Key Assumptions and Research Objectives

We had the following research hypotheses:

- The rational distribution of human activities based on local conditions and the influence of external factors is the mainstay of sustainable development.
- Sustainable development of rural areas is a conscious transformation process during which human needs must be aligned with the needs of the natural environment.
- Sustainable (permanent and multifunctional) development of rural areas requires effective legal, economic, administrative, and technical instruments.
- Geographic information systems and GIS tools support rapid and comprehensive analyses of spatial and environmental phenomena and are useful in the process of generating development forecasts and planning the sustainable development of rural areas.

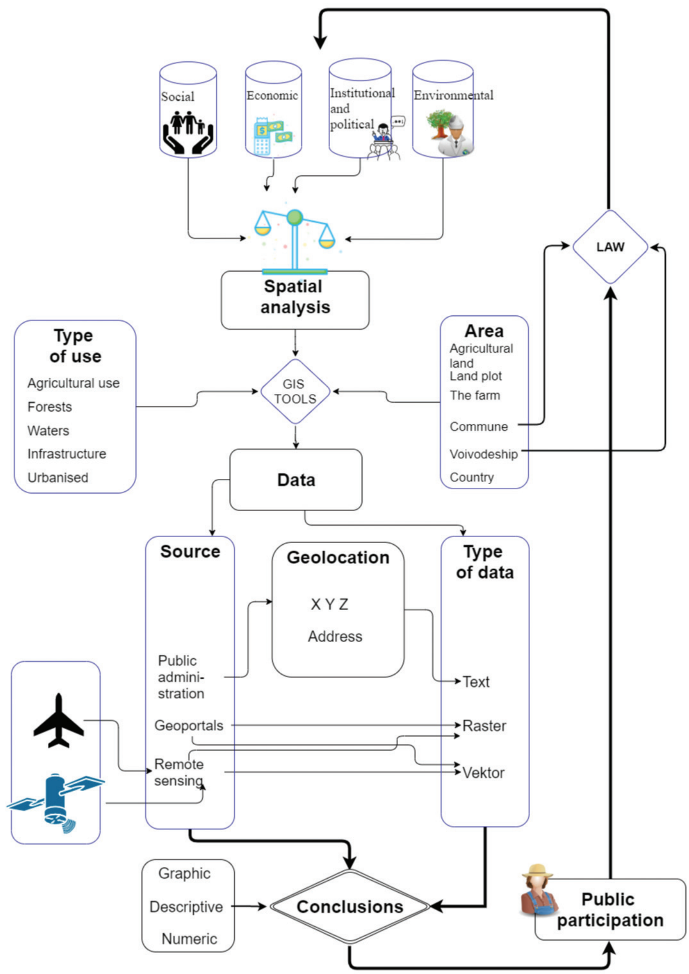

Figure 1. The scope, sources, and applicability of data for spatial analyses. Source: own elaboration.

The main aim of this study was to formulate the principles for using spatial data and spatial analyses in the sustainable development of rural areas. The main research objective entailed the following detailed objectives. The procedure involved several steps, presented in Figure 2.

- To determine the scope, sources, and applicability of data for spatial analyses of phenomena relating to sustainable development.
- To identify the determinants of rural development in view of the main pillars of sustainable development.
- To determine the optimal directions of sustainable development in rural areas.
- To propose a practical approach for the use of spatial tools, methods, and analyses and to develop theoretical and practical procedures for the sustainable development of rural areas.

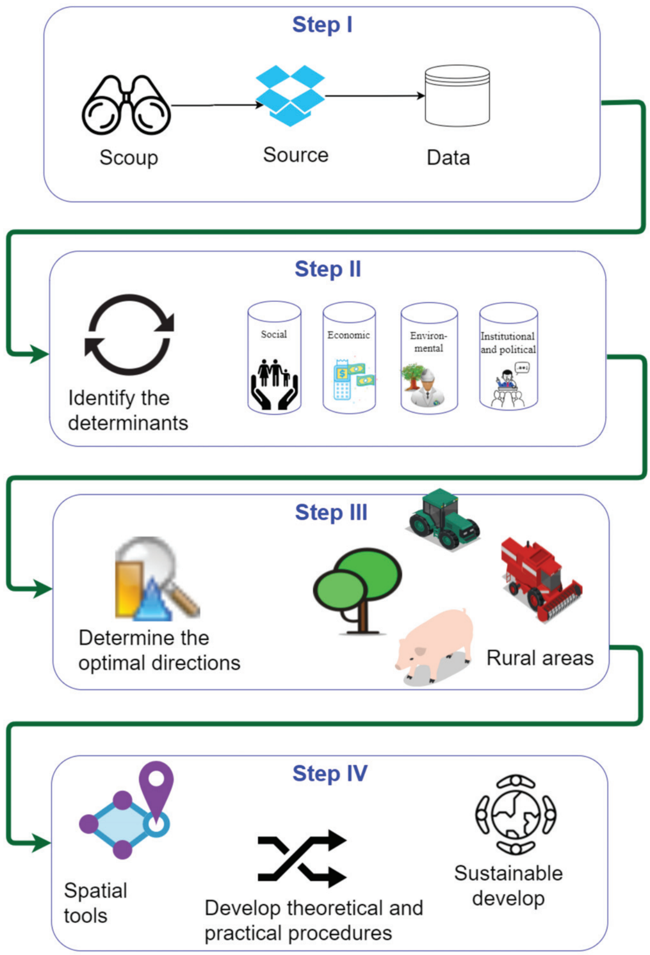

Figure 2. The procedure of using spatial data and spatial analyses in the sustainable development of rural areas. Source: own elaboration.

3. Results and Discussion

3.1. Determination of the Scope, Sources, and Applicability of Data for Spatial Analyses

Space is a highly varied phenomenon, which is why a universal analytical method and growth directions that will guarantee socially, economically, and ecologically sustainable development are difficult to determine. Studies analyzing land management practices should rely on GIS data, tools, and models. Tested solutions as well as innovative methods and new sources of data should be taken into account in land management analyses [63].

The level of socioeconomic development in FLAGs was determined based on GUS data describing the demographic, social, and economic status of municipalities and their infrastructure levels. The scope of input data was narrowed down by analyzing the Local Development Strategies of Fisheries and defining the priorities of the eight analyzed FLAGs.

Different types of data were used in studies analyzing the potential of renewable energy sources, mainly biomass produced by farms in the region of Warmia and Mazury. The analyses were carried out based on the results of a survey conducted in 2012 among biomass producers and biomass processing companies in the region. The number of participants was determined based on the data provided by the employees of Agricultural Advisory Center of the Region of Warmia and Mazury in Olsztyn, specializing in renewable energy sources [59,60]. The spatial distribution of biomass producers and processing companies was determined by geocoding (based on registered address).

The possibilities offered by GIS tools were also discussed in a study evaluating the applicability of photovoltaic panels in road infrastructure. The location of photovoltaic panels powering traffic signs in the Region of Warmia and Mazury was determined based on information obtained from the Regional Directorate for National Roads and Motorways in Olsztyn. Solar-powered traffic signs were localized by manual geocoding with the use of Google Maps [61]. The road authority describes the location of photovoltaic panels based on distance marker posts. The signs are located 1 km apart, and the location of photovoltaic panels was determined based on a public map resource to maximize the geocoding precision. In automatic geocoding, the point of interest is localized along the road axis; therefore, distance marker posts were used to determine the side of the road on which photovoltaic panels had been installed.

A village or town neighboring a national road was identified in the first stage of the study. In the following stage, the location of solar-powered traffic signs was determined based on distance marker posts (Figures 3 and 4).

Figure 3. Estimated location of solar panels on national road No. 16 (Gietrzwałd). Source: [61].

Figure 4. Location of a photovoltaic panel on national road No. 16, distance marker post 38 (Gietrzwałd) (126 + 250 km). Source: [61].

The precise location of photovoltaic panels was determined with the use of Google Maps and the Street View application.

The location of photovoltaic panels was validated based on the nearest distance marker post. Data were compiled in table format, and points were automatically displayed in GIS software.

In [37], the analysis of economic viability was carried out with various variants as a case study of selected plots of agricultural land located in the Regional Directorate of State Forests in Szczecinek in the West Pomeranian Voivodeship. Empirical data were taken from the Szczecinek Forestry Institutions and from individual farmers who carried out afforestation under RDP 2004–2006 and RDP 2007–2013. The average costs of afforestation, support for afforestation in individual RDP periods, as well as average transaction prices of agricultural land were taken into account. The average transaction prices of agricultural land acquired from the Agricultural Property Agency (ANR) in 2004–2016 were adopted for analyses, as the largest afforestation under the RDP was implemented on land acquired from the ANR resource. The data obtained were verified on the basis of industry portals and field research.

3.2. Identification of the Main Determinants of Rural Development in View of the Pillars of Sustainable Development

The original concept of sustainability is based on three pillars, but institutional and spatial domains have been proposed as a fourth pillar of sustainable development. Global trends and challenges associated with minimizing the adverse effects of socioeconomic growth on the environment have led to changes in the concept of sustainable development. According to the Code of Conduct for Responsible Fisheries [64], data relating to social, economic, and institutional factors should be collected and analyzed to promote the sustainable development of fisheries and the achievement of social and economic goals.

Poland is the EU Member State with the largest number of FLAGs. Fisheries Local Action Groups bring together members of local fisheries, municipalities, public institutions, and social organizations and operate based on the adopted development strategies. The majority of funds available under the Fisheries Operational Program 2007–2013 have been dedicated to Priority Axis 4, namely the sustainable development of fisheries. The studies have revealed differences in the absorption of EU funds by Polish FLAGs. In some cases, these variations were associated with the statutes of the analyzed FLAGs and the resulting interpretation problems. Other difficulties resulted from frequent changes in the Local Development Strategies of Fisheries, the number of intermediate agencies, ineffective management of FLAG budgets, and the absence of effective enforcement mechanisms in the supervising institutions. Institutional and political aspects were the main source of problems in FLAGs [35]. These aspects were also identified as the main barrier to growth in the studies, analyzing the prospects for the development of the renewable energy market in the Region of Warmia and Mazury [59,60]. Agriculture is the main source of income in rural areas, and the opportunities created by renewable energy sources and their impact on sustainable and multifunctional development of rural areas have been analyzed [59,60]. The above analyses accounted for social, economic, environmental, institutional, and political aspects of development. A review of the literature [65–73], an analysis of Polish and EU regulations, and the results of our own research were used to identify and verify the key drivers of sustainable development in the analyzed fields of activity in rural areas.

The results of a survey involving biomass producers and processing companies were used to identify the main barriers to the development of the renewable energy market. Interestingly, biomass producers and companies processing biomass identified completely different obstacles to growth.

According to the biomass producers (farmers) surveyed in [59,60], the main barriers to the development of the renewable energy market are the low prices of biomass, the small market, and the absence of stable contracting options. The results of these studies indicate that farmers are not aware of the environmental benefits associated with renewable energy sources. Economic factors are the main drivers of growth in the biomass market [73–75].

A survey of biomass processing companies [59] demonstrated that the absence of legal stability and the shortage of renewable energy support programs are the main barriers to the growth of the renewable energy market. According to the respondents, negative market trends and low levels of infrastructure development exacerbate this problem. The results of [60] revealed that processing companies were unable to harness the potential of the local biomass market. The optimal distance between a biomass production facility and a biomass processing plant has been estimated at 20 km based on a review of the literature. Biomass transport zones have been identified based on the existing road network and are presented in Figure 5.

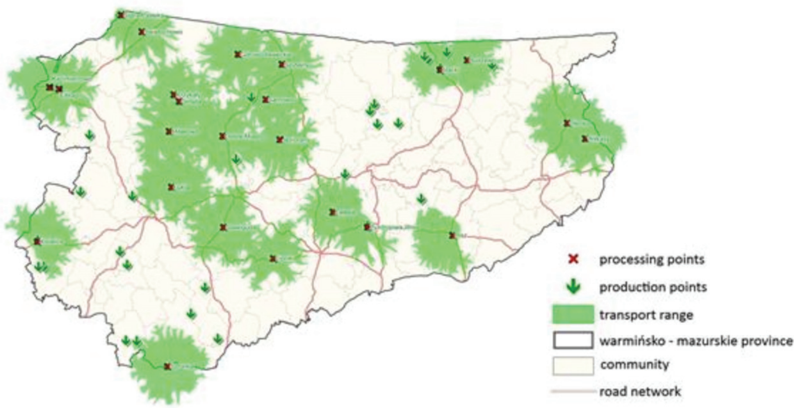

Figure 5. Distribution of biomass producers and processing companies in the Region of Warmia and Mazury. Source: [60].

Transport zones should be distributed uniformly in every region to ensure that the potential of biomass producers and processing companies is fully harnessed (rational localization). The distance between biomass producers and processing companies should be minimized to reduce costs. In the evaluated region, the average distance between biomass producers and processing companies is around 70 km. Biomass is characterized by low energy density (low energy content per unit of volume); therefore, it should be utilized close to the source. Long-distance transport increases costs and has an adverse impact on the natural environment.

A review of the literature [36] indicates that the natural environment is significantly influenced by changes in land use patterns. The relevant research was initiated in the late 19th century and was developed in the mid-20th century. These authors analyzed spatial variations in land use patterns and the influence of natural factors, historical factors, urbanization [76–82], and Common Agricultural Policy (CAP) instruments on changes in the natural environment [83,84]. Similar conclusions were formulated in [36].

In [37], we assessed legal, social, and economic conditions, with a focus on the size of afforestation implemented by individual farmers (beneficiaries of the measure). Since 2004, the value of agricultural land has increased significantly in Poland. Based on the research carried out in [37,85], this is why farmers are reluctant to implement afforestation. The afforestation bonus does not compensate the farmer enough for giving up field cultivation.

The analysis of literature carried out in [37] proved that increasing the forest cover of the country is consistent with the content of resolutions and international agreements to which Poland is a signatory and will serve the goal of improvement of the environment [85]. Degradation of the natural environment is one of the main reasons to implement the afforestation program in both Poland and other EU countries. Poland's membership in the EU and the consequent need to implement the principles of the Common Agricultural Policy is connected with improving the status of areas with unfavorable natural conditions. The Common Agricultural Policy of the EU takes into account the multidimensional interdependencies between agriculture and the natural environment [84]. The revival of land with low agricultural suitability and afforestation positively affects the sustainable development of agriculture and rural areas, both directly and indirectly. The direct impact consists of increasing forest areas and increasing forest cover, thus creating conditions for strengthening ecosystems and biodiversity of rural areas. Indirectly, afforestation provides opportunities for additional employment and income for the rural population.

The price of agricultural land in Poland has increased significantly since 2004. The results of the study revealed that this is the main reason why farmers are reluctant to participate in afforestation projects. Afforestation premiums do not compensate for the loss in income from the production of field crops.

The key determinants of sustainable development in rural areas have been identified in view of internal and external factors, including the CAP. The opportunities and barriers to the sustainable development of rural areas are presented in Table 1.

Table 1. The opportunities and barriers to the sustainable development of rural areas.

Pillar of Sustainable Development	Determinants
	Barriers/Negative Factors
Social	Low levels of awareness relating to the significance: noneconomic functions of local associations develop of renewable energy sources and photovoltaic systems noneconomic functions of forests Rapid urbanization
Economic	Production limits in sea fisheries and lower employment in the fisheries sector Barriers to business growth (unstable market of farming supplies and agricultural produce) Economic factors are the main drivers of business growth (production)
Environmental	Environmental degradation Loss of land used in agricultural production Intensification of production
Institutional and political	Legal instability (frequent changes in legal regulations) Differences in the operating principles of FLAGs and the resulting interpretation problems Frequent changes in the Local Development Strategies of Fisheries Lack of programs to support renewable energy Ineffective management of the CAP budget Absence of renewable energy support programs Changes in the CAP principles Lack of stable legal basis
	Opportunities/Positive Factors
Social	Higher standard of living Promoting the concept of sustainable development Development of services and higher service quality Development of social capital Activation of local communities Improved road traffic safety
Economic	Additional source of income for rural residents New employment opportunities outside the fisheries sector Diversification of agricultural production Financial support under the CAP Management of surplus production and agricultural wastes Energy security
Environmental	Protection of natural resources Improved quality of the natural environment, including water quality Promotion of environmentally friendly solutions (renewable energy) Slowing down the exploitation of natural resources and minimizing pollution Higher forest cover
Institutional and political	Financial support for technological development Goal performance based on development strategies Involvement of local partners in decision-making Public-private partnership

Notes: Source: own elaboration.

3.3. Determination of the Optimal Directions of Sustainable Development in Rural Areas

Development strategies that account for human needs and the environment play a very important role at the local level, in particular in rural areas. A sustainable development framework can be proposed based on an evaluation of the observed phenomena.

Diverse land-use patterns are introduced to increase the percentage of land not used for agricultural purposes and to decrease the share of agricultural production in rural incomes [36]. In fisheries, sustainable development strategies include limits on fish production and the creation of new employment opportunities outside the fisheries sector [35].

Agriculture is closely related to energy policy. Energy crops have the potential to become an agricultural product of strategic importance, thus increasing the share of biofuels in the overall energy balance, improving energy supplies, and contributing to the achievement of energy policy goals [75]. Energy crops can also increase the profitability of agricultural production and improve the socioeconomic status of rural residents. However, not all areas characterized by an abundance of low-quality soils are suitable for the cultivation of energy crops. The long-term goal of the energy policy is to turn Polish rural areas into segments of an innovative economy [36,86].

The results of a survey presented in [59] revealed certain differences in the opinions expressed by biomass producers and companies that convert biomass into energy. Most respondents agreed that the absence of systemic incentives is the main barrier to the growth of the renewable energy market. The farmers and companies polled are aware that renewable energy plays a very important role in sustainable development, but in their opinion, the existing support programs are insufficient. Stable sources of raw materials are required for biomass production and conversion into energy. The renewable energy market provides farmers and businesses with a new opportunity for diversifying their sources of income. However, these measures necessitate changes in the production profile, the search for new markets, effective transportation, and specialist machines and equipment.

Based on a review of the literature, the authors of [36] postulate that space is a limited commodity. The area dedicated to food crops per capita continues to decrease [80]. The above results from the use of agricultural land for nonfarming purposes, mainly for afforestation and urbanization, as well as steady population growth. In this context, rational management of space, in particular agricultural land, takes on a new significance. Agricultural production in rural areas increased after Poland joined the European Union. A significant decrease was observed in the area of land that had been kept temporarily fallow [87]. These changes can be attributed to the availability of EU structural funds. Farm area is an important determinant of changes in land use structure. In a market economy, Polish farmers have to increase their output to derive a satisfactory income. When the demand for agricultural products is stable, the above goal can only be achieved by increasing the farm area [88].

Various programs and support measures creating sustainable development have been implemented in agriculture and forestry. Many of these projects have been initiated as part of the obligations undertaken by Poland under international agreements. The main aim of these measures is to achieve climate neutrality.

3.4. Practical Application of the Applied Tools and Methods of Spatial Analysis and the Development of Theoretical and Practical Procedures for Sustainable Development of Rural Areas

Data collection and the selection of the appropriate methods and tools are very important considerations in a spatial analysis. These observations have been confirmed in [35,36], which relied on data generated by the Central Statistical Office. Spatial analyses are highly useful for evaluating social, demographic, and economic phenomena.

The absorption rate of EU funds significantly influences the directions of sustainable development in rural areas. Measures that support sustainable development have to be monitored because the principles governing the availability of EU funding for various projects change with every financial framework. The detailed regulations governing the availability of funding for various projects are set in domestic laws. Legal regulations have to be constantly amended to account for socioeconomic changes. The availability and distribution of EU funds have to be controlled to eliminate adverse phenomena. The existing GIS can be expanded to create an integrated system where all payments are controlled in real time. The proposed system would also facilitate the evaluation of grant applications.

However, more complex methods may be required to evaluate space and the uneven distribution of the analyzed processes. Complex and detailed analyses that can be performed within a short time are becoming increasingly popular.

The authors of [59,60] proposed a useful tool facilitating biomass management for energy generation. Data relating to the biomass market should be combined with local conditions to optimize biomass production and processing. The phenomena associated with the development of the renewable energy market can be visualized to support farmers in the process of adapting to the current market situation and to provide biomass processing companies with valid information about the availability of biomass sources. The authors of [59] compiled a map of biomass producers and biomass processing companies. They analyzed 11 measures that influence the biomass market and identified three key problem areas: financial support for the biomass market (subsidies), a stable energy policy, and education (Figure 6). The results confirmed considerable spatial variations in the observed phenomena. Spatial analyses should take into account local conditions, and the spatial distribution of the expectations voiced by biomass processing companies is the best example of the above. Local conditions include farm area, production profile, degree of mechanization, and support from the competent institutions and local authorities. Such analyses support decision-making and enable market participants to make the most of existing opportunities. In rural areas, the development of the renewable energy market can significantly contribute to the activation of local communities, as discussed in Section 3.3.

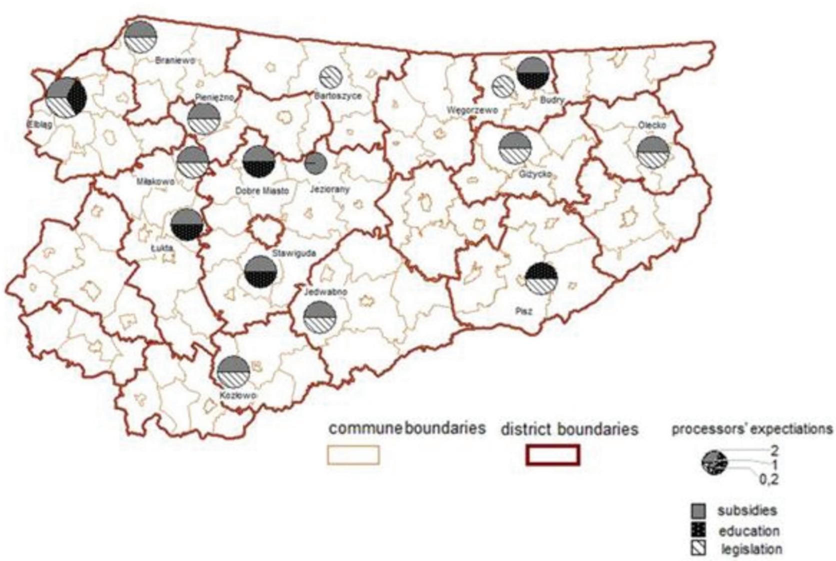

Figure 6. The required measures supporting the development of the biomass market according to the surveyed biomass processing companies in the Region of Warmia and Mazury. Source: [59].

In [60], the physical distance between biomass producers and biomass processing companies was mapped based on the existing road network. The resulting raster map (network of regular cells with identical size and shape) emphasized the continuity of the analyzed phenomena, and it was used to analyze the problem from a completely different perspective. The map indicates areas that require special attention due to a shortage of biomass processing companies. The majority of companies converting biomass into energy are separated by a considerable distance from biomass producers. The process of mapping geographic distances is relatively simple; however, it was initially complex in the discussed example because road distances had to be manually calculated, and the isolines between road sections had to be manually interpolated. The use of computer tools, in particular GIS, significantly accelerated that process and improved the quality of the results (Figure 7).

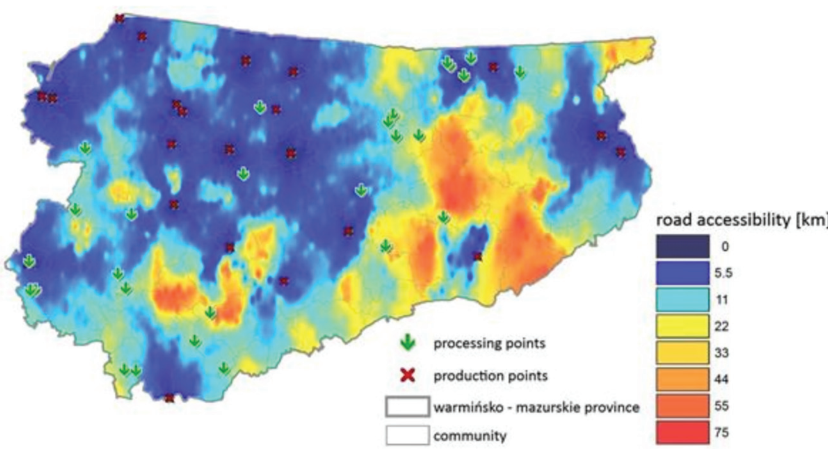

Figure 7. Travel time between biomass producers and biomass processing plants (warm colors denote longer travel time). Source: [60].

The Geographic Information System supports the integration of various types of data obtained from numerous sources and stored in different formats. The quality of the collected, processed, and released data is visibly improved. The resulting information is easier to find and interpret, which supports the formulation of accurate conclusions. Various types of spatial data and databases can be processed with the use of GIS tools. Statistical data from the Energy Regulatory Office, the Agricultural Advisory Center in the Region of Warmia and Mazury, and Geoportal data can be imported and displayed in layers as maps and attribute tables presenting biomass production and processing in the region [60]. These data can also be processed with the use of GIS tools for other spatial analyses.

GIS tools can also be deployed to monitor and manage the renewable energy market. Thematic maps developed with the use of various types of data support the integration of all actors on the biomass market. GIS tools are highly useful for presenting processed data to various groups of stakeholders.

The authors of [60] proposed an integrated system for biomass production, processing, and the distribution of biomass-derived energy. The establishment of local distributed energy centers in rural areas would substantially improve the efficiency of energy generation from biomass [61].

The analysis conducted in publication [61] demonstrated that the process of generating a map with the use of geocoding is highly laborious and time-consuming. Not all objects can be accurately positioned on a map due to the limited availability of valid satellite images. The geocoding process has to be automated when working with large datasets. Popular geocoding tools mainly rely on address points from large databases (up to 80 million address points) and support automatic and highly accurate determinations of the object's longitude and latitude (Figure 8).

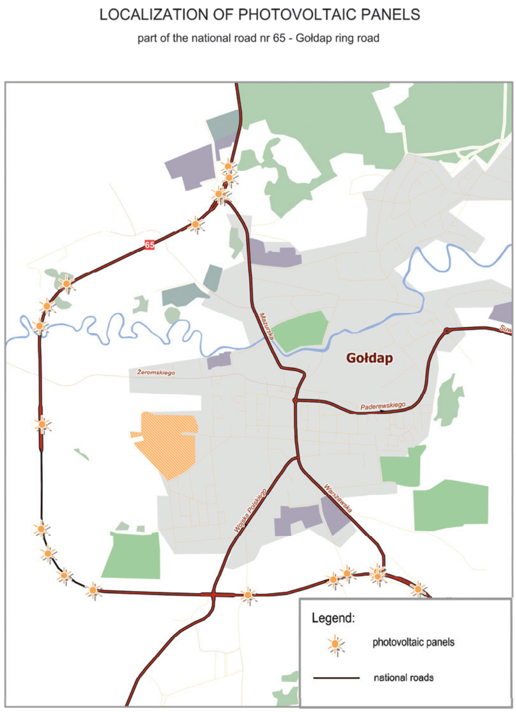

Figure 8. Location of signs powered by photovoltaic technology on the Gołdap bypass. Source: [61].

GIS tools continue to evolve, which improves access to information and increases database managers' awareness that highly accurate data are needed for spatial analyses. The scope of data relating to roads and the accompanying infrastructure has also been significantly expanded in recent years.

A comprehensive database relating to road networks and the location of distance marker points would support the development of a geocoding tool that automatically assigns geographical coordinates to all objects along roads. With the use of the proposed tool, objects that are localized in numerous databases and described only with the use of distance marker points could be automatically transferred to maps (GIS software) and automatically managed. The described process of positioning photovoltaic panels for powering traffic signs is one of many examples of how databases can be used in geocoding. Such solutions could also be used to improve transport safety in rural (nonurbanized) areas, i.e., to designate dangerous places (where there are frequent road accidents), pedestrian crossings, etc.

4. Conclusions

The study describes the applicability of GIS tools for the sustainable development of rural areas:

- The informative and functional value of source data was determined in view of the aim, scope, and time framework of spatial analyses.
- The main determinants of sustainable development were identified and indicators for monitoring sustainable development measures were proposed.
- The optimal directions of sustainable development were identified in view of changing external circumstances, including legal, social, and economic.
- The applicability of GIS tools as instruments that support vital decision-making processes in the implementation of sustainable development principles was discussed.

The main determinants of growth in agricultural areas, forests, and fisheries were defined based on the main sources of income in rural communities. The implemented measures have to be continuously monitored to guarantee that they serve the intended purpose. The data, methods, and tools that are most appropriate for the research objective, scope of study, and analyzed area have to be selected. The acquisition of the most relevant data is the key to success. In many cases, the relevant data can be obtained only from institutions responsible for the implementation of a given program or task. For an integrated GIS to be developed based on the provisions of the INSPIRE Directive, these data have to be made available to the public. The results of the study emphasize the need for a pan-European geographic information system that facilitates the identification of various spatial phenomena, contributing to decision-making in the localization process and the identification of the key determinants of sustainable growth. These efforts require consistent development strategies, a rational spatial policy, and legal regulations that define the goals of sustainable development. The success of this undertaking will be largely determined by the cohesiveness and applicability of GIS data and the effectiveness of monitoring.

Creating and sharing spatial data in digital form is not only good practice but is also regulated by specific legal acts. Currently created in Poland under the INSPIRE Directive, map portals and the widely available General Geographic Object Databases offer a reliable, current, and continuous source of spatial information for the entire country, extremely helpful in the planning process at various levels of generalization. The database implemented into the Spatial Information System is its most important element and should constitute a complete and reliable representation of elements of the real world.

GIS systems allow us to formulate models in a structured and formal way to reflect both the current situation and forecast changes that will occur in space when certain conditions are met.

The proposed methodology can be used in practical applications:

- Preparing planning studies, both regarding spatial policy and local law, as well as in economic planning and shaping the structure of rural space (structure of ownership and structure of use).
- The development of thematic spatial information systems related to planning studies and works shaping the rural space.
- Reports submitted to Polish and EU authorities relating to the utilization of funds dedicated to rural development in the multiannual financial framework and modification of the implemented actions.
- The use of renewable energy sources to improve Poland's energy security.

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References

1. Łuszczyk, M. Koncepcja rozwoju zrównoważonego w polityce ekologicznej państwa. In *Ekologiczne Problemy Zrównoważonego Rozwoju*; Kiełczewski, D., Dobrzańska, B., Eds.; Wydawnictwo Wyższej Szkoły Ekonomicznej w Białymstoku: Warszawa, Poland, 2009; pp. 49–60.

2. Redclift, M. Sustainable development (1987–2005): An oxymoron comes of age. *Sustain. Dev.* **2005**, *13*, 212–227. [CrossRef]
3. World Commission on Environment and Development & Brundtland Commission. Our Common Future, Brundtland Report. In *Proceedings of the Report of the World Commission on Environment and Development to the Commission of the European Communities, the EC and EFTA Countries, Brussels, Belgium, 5 May 1987*; World Commission on Environment and Development: Brussels, Belgium, 1987.
4. Act on Environmental Protection and Management of 31 January 1980. *J. Laws* **1994**, *49*, 196.
5. Act on Environmental Protection Law of 27 April 2001. *J. Laws* **2020**, 1219.
6. Constitution of the Republic of Poland of 7 April 1997. *J. Laws* **1997**, *78*, 483.
7. Hopwood, B.; Mellor, M.; O'Brien, G. Sustainable development: Mapping different approaches. *Sustain. Dev.* **2005**, *13*, 38–52. [CrossRef]
8. Marks-Bielska, R. Chosen aspects of sustainable development in Poland with particular focus on agriculture. In *Management Theory and Studies for Rural Business and Infrastructure Development*; 2. Research Papers; Lithuanian University of Agriculture: Kaunas, Lithuania, 2011.
9. Pretty, J.N. Participatory learning for sustainable agriculture. *World Dev.* **1995**, *23*, 1247–1263. [CrossRef]
10. Reganold, J.P.; Papendick, R.I.; Parr, J.F. Sustainable agriculture. *Sci. Am.* **1990**, *262*, 112–121. [CrossRef]
11. DeLonge, M.S.; Miles, A.; Carlisle, L. Investing in the transition to sustainable agriculture. *Environ. Sci. Policy* **2016**, *55*, 266–273. [CrossRef]
12. McCormick, K.; Anderberg, S.; Coenen, L.; Neij, L. Advancing sustainable urban transformation. *J. Clean. Prod.* **2013**, *50*, 1–11. [CrossRef]
13. Shen, L.; Zhou, J. Examining the effectiveness of indicators for guiding sustainable urbanization in China. *Habitat Int.* **2014**, *44*, 111–120. [CrossRef]
14. Shen, L.; Shuai, C.; Jiao, L.; Tan, Y.; Song, X. A global perspective on the sustainable performance of urbanization. *Sustainability* **2016**, *8*, 783. [CrossRef]
15. Satterthwaite, D. Sustainable cities or cities that contribute to sustainable development? *Urban. Stud.* **1997**, *34*, 1667–1691. [CrossRef]
16. Bibri, S.E.; Krogstie, J. Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustain. Cities Soc.* **2017**, *31*, 183–212. [CrossRef]
17. Hunter, C. Sustainable tourism as an adaptive paradigm. *Ann. Tour. Res.* **1997**, *24*, 850–867. [CrossRef]
18. Buckley, R. Sustainable tourism: Research and reality. *Ann. Tour. Res.* **2012**, *39*, 528–546. [CrossRef]
19. Dempsey, N.; Bramley, G.; Power, S.; Brown, C. The social dimension of sustainable development: Defining urban social sustainability. *Sustain. Develop.* **2011**, *19*, 289–300. [CrossRef]
20. Murphy, K. The social pillar of sustainable development: A literature review and framework for policy analysis. *Sustain. Sci. Pract. Policy* **2012**, *8*, 15–29. [CrossRef]
21. Eizenberg, E.; Jabareen, Y. Social sustainability: A new conceptual framework. *Sustainability* **2017**, *9*, 68. [CrossRef]
22. Missimer, M.; Robèrt, K.H.; Broman, G. A strategic approach to social sustainability–Part 1: Exploring the social system. *J. Clean. Prod.* **2017**, *140*, 32–41. [CrossRef]
23. Daly, H.E. *Ecological Economics and Sustainable Development*; Edward Elgar Publishing: Cheltenham, UK, 2007.
24. Lawn, P.A. *Toward Sustainable Development: An Ecological Economics Approach*; CRC Press: Boca Raton, FL, USA, 2000.
25. Czaja, S.; Becla, A. Wybrane informacyjne problemy definiowania zrównoważonego i trwałego rozwoju–ujęcie teoretyczne. [Selected information problems of defining sustainable development: A theoretical analysis]. *Optimum. Studia Ekonomiczne* **2016**, *1*. [CrossRef]
26. *Wskaźniki rozwoju zrównoważonego Polski [Sustainable development indicators]*; GUS: Katowice, Poland, 2011; ISBN 978-83-89641-04-5.
27. *Wskaźniki rozwoju zrównoważonego [Sustainable development indicators]*; GUS: Katowice, Poland, 2015; ISBN 978-83-89641-54-0.
28. Alexander, E.R. Institutional design for sustainable development. *Town Plan. Rev.* **2006**, *77*, 1–27. [CrossRef]
29. Rahman, H.M.; Saint Ville, A.; Song, A.; Po, J.; Berthet, E.; Brammer, J.; Reed, G. A framework for analyzing institutional gaps in natural resource governance. *Int. J. Commons* **2017**, 11. [CrossRef]
30. MombeuiL, C. Institutional conditions, sustainable energy, and the UN sustainable development discourse: A focus on Haiti. *J. Clean. Prod.* **2020**, *254*, 120153. [CrossRef]
31. Kryszk, H.; Kurowska, K.; Brodziński, Z. Identification of renewable energy sources in the region of Warmia and Mazury with the use of mapinfo professional software. In *GIS and its Implementations*; Źróbek, R., Kereković, D., Eds.; Croatian Information Technology Society, GIS Forum: Zagreb, Croatia, 2013; pp. 136–148.
32. Kryszk, H.; Kurowska, K. Photovoltaics as a source of renewable energy and a new area of activity in rural areas. *Studia Obsz. Wiej.* **2014**, *35*, 255–272.
33. Kurowska, K.; Kryszk, H. The use of funds for agri-environmental measures in the Warmińsko-Mazurskie Voivodship in 2007–2013. *Studia Obszarów Wiejskich* **2013**, *34*, 205–220.
34. Kurowska, K.; Kryszk, H.; Marks-Bielska, R.; Kietlińska, E. Spatial analysis of afforestation in Poland under rural development programme 2007–2013. In Proceedings of the Annual 20th International Scientific Confference Proceedings Research for Rural Development 2014, Jelgava, Latvia, 21–23 May 2014.

35. Kurowska, K.; Kryszk, H.; Gwiaździńska-Goraj, M. Sustainable development of coastal areas-Polish experience following accession to the European Union based on the example of Fisheries Local Action Groups (FLAGs) during 2007–2013. *Acta Adriatica* **2014**, *55*, 163–178.
36. Kurowska, K.; Rudnicki, R. Changes in land use in Poland—Comparative study of period 2002–2010. In Proceedings of the The 7th International Scientific Conference Rural Development 2015: Towards the Transfer of Knowledge, Innovations and Social Progress, Kaunas, Lithuania, 9–20 November 2015. [CrossRef]
37. Kurowska, K.; Kryszk, H. Profitability of the farmland afforestation within the Rural Development Programme. *Sylwan* **2017**, *161*, 1035–1045.
38. Jeżowski, P. Kategoria rozwoju zrównoważonego w naukach ekonomicznych. In *Ekonomiczne Problemy Ochrony Środowiska I Rozwoju Zrównoważonego W XXI Wieku*; Jeżowski, P., Ed.; Oficyna Wydawnicza Szkoły Głównej Handlowej: Warszawa, Poland, 2007.
39. Mitchell, G. Problems and fundamentals of sustainable development indicators. *Sustain. Dev.* **1996**, *4*, 1–11. [CrossRef]
40. Tasaki, T.; Kameyama, Y.; Hashimoto, S.; Moriguchi, Y.; Harasawa, H. A survey of national sustainable development indicators. *Int. J. Sustain. Dev.* **2010**, *13*, 337–361. [CrossRef]
41. Borys, T. (Ed.) *Wskaźniki Ekorozwoju*; Wydawnictwo Ekonomia i Środowisko: Białystok, Poland, 1999.
42. Alexander, E.R.; Mazza, L.; Moroni, S. Planning without plans? Nomocracy or teleocracy for social-spatial ordering. *Prog. Plan.* **2012**, *77*, 37–87. [CrossRef]
43. Podciborski, T.; Krzywnicka, I. A method for evaluating the peripherality of rural settlement units based on the principles of spatial order and sustainable development. *Barometr Regionalny. Analizy i prognozy* **2015**, *1*, 27–32.
44. Różycka-Czas, R.; Salata, T.; Gawroński, K.; Czesak, B.; Cegielska, K. The use of geographic information systems to spatial order evaluation. *Acta Sci. Pol. Form. Circumiectus* **2016**, *15*, 73. [CrossRef]
45. Bina, O. The green economy and sustainable development: An uneasy balance? *Environ. Plan. C Gov. Policy* **2013**, *31*, 1023–1047. [CrossRef]
46. Aldieri, L.; Vinci, C.P. Green economy and sustainable development: The economic impact of innovation on employment. *Sustainability* **2018**, *10*, 3541. [CrossRef]
47. Lavrinenko, O.; Ignatjeva, S.; Ohotina, A.; Rybalkin, O.; Lazdans, D. The role of green economy in sustainable development (case study: The EU states). *Entrep. Sustain. Issues* **2019**, *6*, 1013–1026. Available online: https://jssidoi.org/jesi/article/273 (accessed on 7 September 2020). [CrossRef]
48. Janoušková, S.; Hák, T.; Moldan, B. Global SDGs assessments: Helping or confusing indicators? *Sustainability* **2018**, *10*, 1540. [CrossRef]
49. Cloke, P.J.; Doel, M.A.; Matless, D.; Thrift, N.; Phillips, M. *Writing the Rural: Five Cultural Geographies*; Sage: London, UK, 1994.
50. Cloke, P.J. (Ed.) *Country Visions*; Pearson Education: New York, NY, USA, 2003.
51. Coburn, A.F.; MacKinney, A.C.; McBride, T.D.; Mueller, K.J.; Slifkin, R.T.; Wakefield, M.K. Choosing rural definitions: Implications for health policy. *Rural Policy Res. Inst. Health Panel* **2007**, *2*, 1–8.
52. Ilbery, B. Dimensions of rural change. In *The Geography of Rural Change*; Ilbery, B., Ed.; Routledge: London, UK, 1998; pp. 1–10.
53. Bański, J.; Mazur, M. Classification of rural areas in Poland as an instrument of territorial policy. *Land Use Policy* **2016**, *54*, 1–17. [CrossRef]
54. Lanfranchi, M.; Giannetto, C. Sustainable development in rural areas: The new model of social farming. *Calitatea* **2014**, *15* (Suppl. S1), 219.
55. Bansal, V.K. Use of geographic information systems in spatial planning: A case study of an institute campus. *J. Comput. Civil Eng.* **2014**, *28*, 05014002. [CrossRef]
56. Linsenbarth, A.; Ney, B.; Wysocka, E. Concept of the Polish spatial information system. In Proceedings of the 7th EC GI&GIS Workshop, Potsdam, Germany, 13–15 June 2001.
57. *Directive INSPIRE 2007/2/EC of European Parliament and the Council of 14 March 2007 Establishing an Infrastructure for Spatial Information in the European Community*; European Commission: Brussels, Belgium, 2007.
58. *Council Regulation (EC). No. 1198/2006 of 27 July 2006 on the European Fisheries Fund*; European Commission: Brussels, Belgium, 2006.
59. Brodziński, Z.; Kryszk, H.; Kurowska, K. Market of producers and processors of agricultural biomass for energy purposes. *Pol. J. Environ. Stud.* **2014**, *23*, 619–628.
60. Kurowska, K.; Kryszk, H.; Bielski, S. Determinants of biomass production for energy purposes in North-Eastern Poland. In Proceedings of the 13th International Scientific Conference on Engineering for Rural Development, Jelgava, Łotwa, 29–30 May 2014; pp. 417–422.
61. Kurowska, K.; Kryszk, H.; Kietlińska, E. Photovoltaics as an element of intelligent transport system development. In *Geoinformatics for Intelligent Transportation*; Springer: Cham, Switzerland, 2015; pp. 187–199. [CrossRef]
62. Bibby, P.; Shepherd, J. GIS, land use, and representation. *Environ. Plan. B Plan. Des.* **2000**, *27*, 583–598. [CrossRef]
63. Brzuchowska, J. Proposals of transportation phenomena analysis based on raster maps and GIS tools. *Tech. Trans.* **2010**, *3*, 125–138.
64. Van Iseghem, S.; Quillérou, E.; Brigaudeau, C.; Macher, C.; Guyader, O.; Daurès, F. Ensuring representative economic data: Survey data-collection methods in France for implementing the Common Fisheries Policy. *ICES J. Mar. Sci.* **2011**, *68*, 1792–1799. [CrossRef]
65. Waheed, R.; Chang, D.; Sarwar, S.; Chen, W. Forest, agriculture, renewable energy, and CO_2 emission. *J. Clean. Prod.* **2018**, *172*, 4231–4238. [CrossRef]

66. Chel, A.; Kaushik, G. Renewable energy for sustainable agriculture. *Agron. Sustain. Dev.* **2011**, *31*, 91–118. [CrossRef]
67. Fan, Y.; Lee, A.; Parker, N.; Scheitrum, D.; Dominguez-Faus, R.; Jaffe, A.M.; Medlock III, K. Geospatial, temporal and economic analysis of alternative fuel infrastructure: The case of freight and US natural gas markets. *Energy J.* **2017**, 38. [CrossRef]
68. Romański, L.; Bukowski, P.; Dębowski, M. Analysis of using renewable energy in rural farms. *Agric. Eng.* **2012**, *2*, 137.
69. Stolarski, M. Prospects for the use of renewable energy sources. In *Current Status and Prospects of Development of Rural Areas in the Warmia-Mazury 2020*; Brodziński, Z., Ed.; Samorząd Województwa Warmińsko-Mazurskiego: Olsztyn, Poland, 2012; pp. 79–98. (In Polish)
70. Noon, C.E.; Daly, M.J. GIS-based biomass resource assessment with BRAVO. *Biomass Bioenergy* **1996**, *10*, 101–109. [CrossRef]
71. Fiorese, G.; Guariso, G. A GIS-based approach to evaluate biomass potential from energy crops at regional scale. *Environ. Model. Softw.* **2010**, *25*, 702–711. [CrossRef]
72. Jasiulewicz, M. Possibility of liquid bio-fuels, electric and heat energy production from biomass in polish agriculture. *Pol. J. Environ. Stud.* **2010**, *19*, 480.
73. Jezierska-Thöle, A.; Rudnicki, R.; Kluba, M. Development of energy crops cultivation for biomass production in Poland. *Renew. Sustain. Energy Rev.* **2016**, *62*, 534–545. [CrossRef]
74. Hauk, S.; Knoke, T.; Wittkopf, S. Economic evaluation of short rotation coppice systems for energy from biomass—A review. *Renew. Sustain. Energy Rev.* **2014**, *29*, 435–448. [CrossRef]
75. Testa, R.; Di Trapani, A.M.; Foderà, M.; Sgroi, F.; Tudisca, S. Economic evaluation of introduction of poplar as biomass crop in Italy. *Renew. Sustain. Energy Rev.* **2014**, *38*, 775–780. [CrossRef]
76. Falkowski, J.; Kostrowicki, J. *Geografia Rolnictwa Świata [Geography of Agriculture in the World]*; PWN: Warszawa, Poland, 2001.
77. Uhorczak, F. Użytkowanie ziemi i rolnictwo [Land use and agriculture]. In *Geografia Powszechna*; Barbag, J., Ed.; PWN: Warszawa, Poland, 1963; p. 268. 2012.
78. Łowicki, D. Land use changes in Poland during transformation: Case study of Wielkopolska region. *Landsc. Urban Plan.* **2008**, *87*, 279–288. [CrossRef]
79. Kulikowski, R. *Zmiany w kierunkach użytkowania gruntów ornych w Polsce w latach 1958–1965*, Przegląd Geograficzny [*Changes in trends of arable land use in Poland in 1958–1965*]. *Geogr. Rev.* **1969**, *41*, 2.
80. Bański, J. *Przemiany Rolniczego Użytkowania Ziemi w Polsce w Latach 1975–1988, Prace Geograficzne, [Changes in Agricultural Land Use in Poland in 1975–1988, Geographical Studies]*; IGiPZ PAN: Warszawa, Poland, 1997; p. 168.
81. Cegielska, K.; Noszczyk, T.; Kukulska, A.; Szylar, M.; Hernik, J.; Dixon-Gough, R.; Kovács, K.F. Land use and land cover changes in post-socialist countries: Some observations from Hungary and Poland. *Land Use Policy* **2018**, *78*, 1–18. [CrossRef]
82. Noszczyk, T. Land use change monitoring as a task of local government administration in Poland. *J. Ecol. Eng.* **2018**, *19*, 170–176. [CrossRef]
83. Kiryluk-Dryjska, E.; Beba, P.; Poczta, W. Local determinants of the Common Agricultural Policy rural development funds' distribution in Poland and their spatial implications. *J. Rural Stud.* **2020**, *74*, 201–209. [CrossRef]
84. Kołodziejczak, A.; Rudnicki, R. Common Agricultural Policy instruments aiming at improvement of natural environment in the context of spatial planning in agriculture. *Acta Sci. Polonorum. Adm. Locorum* **2012**, *11*, 117–133.
85. *Update of the National Program for Increasing Woodness*; Ministry of the Environment: Warsaw, Poland, 2003.
86. Marks-Bielska, R.; Bielski, S. The increasing role of agriculture to ensure national energy security. *Wies i Rolnictwo* **2013**, *4*, 149–160.
87. Kulikowski, R. Produkcja i towarowość rolnictwa w Polsce. Przemiany i zróżnicowanie przestrzenne po II wojnie światowej, Prace Geograficzne [Agricultural production and market ability in Poland. Changes and spatial diversification after World War II.]. *Geogr. Stud.* **2013**, *241*, 122.
88. Ziętara, W. Model of Polish agriculture—In the face of current challenges. *Zesz. Nauk. Sggw. Ekon. I Organ.* **2009**, *73*, 5–21.

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