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Environmental Identities and the Sustainable City. The Green Roof Prospect for the Ecological Transition

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Abstract: This research deals with the issue of the recovery of the historic urban fabric with a view towards ecological transition, nowadays considered the preferable direction of sustainability for the reform of the house–city–landscape system. The massive incentives provided by the Italian government for sustainable building, in view of the post-pandemic economic recovery, risk being reduced to mere support for the real estate sector, which turns the financial transfer from the public into an increase in asset value for the private sector. Such an incentive system could contradict the original function of the city, which is to be the privileged place for social communication and the creation of the identity of settled communities. A process of property development that disregards the distribution of income favors the most valuable property, thus increasing the socioeconomic distance between centrality and marginality. The latter is a condition that often characterizes the parts of the historic city affected by extensive phenomena of physical and functional obsolescence of the built heritage, and it is less capable of attracting public funding. The increase of building decay and social filtering-down accelerates the loss and involution of neighborhood identities; the latter constitutes the psycho-social energy that helps preserve the physical, functional and anthropological integrity of the city, due to the differences that make its parts recognizable. This study, with reference to a neighborhood in the historic city of Syracuse (Italy), proposes a model of analysis, evaluation and planning of interventions on the buildings' roofs, aimed at defining the best strategy for ecological–environmental regeneration. The model presented allows one to generate a multiplicity of alternative strategies that combine different uses of roofs: from the most sustainable green roofs, but that are less cost-effective from the identity and landscape point of view; to the most efficient photovoltaic roofs from the energy–environmental point of view; and up to the most cost-effective ones, the vertical extensions with an increase in building volume. The proposed tool is an inter-scalar multidimensional valuation model that connects the multiple eco-socio-systemic attitudes of individual buildings to the landscape, identity, energy–environmental and economic overall dimensions of the urban fabric and allows one to define and compare multiple alternative recovery hypotheses, evaluating their potential impacts on the built environment. The model allows the formation of 100 different strategies, which are internally coherent and differently satisfy the above four perspectives, and it provides the preferable ones for each of the five approaches practiced. The best strategy characterizes most green roofs, 427 out of 1075 building units, 277 blue roofs, 121 green–blue roofs and 46 grey roofs.

Keywords: green roofs; ecological transition; appraisal; multicriteria valuation; option generation; strategic programming; National Recovery and Resilience Plans—NRRP

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1. Introduction

1.1. Disciplinary Issues. Valuation and Project

This research is part of one of the many fields of application of the science of evaluation and, in particular, its disciplinary development in studies on the territory and the city, inaugurated by Carlo Forte [1], who inspired an extensive field of research on the analysis, evaluation and management of urban regeneration programs [2–8].

Within such a disciplinary frame, many methodological patterns and operational experiences focusing on land, city and historic urban fabrics [9–13], over time, have laid the foundations for a greater awareness of the relationship between evaluation and the project; this work aims to make a further contribution to this thematic extension [14–16].

The commitment of Appraisal Science in urban planning and management consists in basing urban planning choices on the building–urban values involved (opportunity costs) [17] and on the economic prospects of the building and architectural and urban heritage (benefits) [18].

1.2. The House–City–Landscape System from a Green Perspective

In this proposal, the aforementioned disciplinary orientations align with the more general theme of the green turn, which, for several decades, has been calling for policies to support the economy in order to overcome its structural cyclicality. A decisive acceleration in this sense was given by the recent "green deal" [19,20], which took shape within the EU [21]; it identified measures to support the new forms of circular economy [22], in the more general prospect of inter-generational fairness [23], as well as in the more specific issue of urban green regeneration.

The metabolization of the ecological–environmental issue in social behaviors and practices has reoriented the global monetary policies [24], today strongly supported in Europe by massive financing for economic recovery [25,26], towards the prospect of the green-digital transition.

The ultimate target of such supporting actions is the global benefit for the cities, which is the maximum expression of their house–city–landscape system dimension [27,28]. A house–city–landscape system is made by the formal unity and coexistence of modes of dwelling, the interaction of the latter with the urban evolution and the rules that make a settled community efficient. Accordingly, several measures concern building and energy retrofitting [29,30], as well as the enhancement of "public beauty" [31,32] in the prospect of both the urban community's identity strengthening and social–territorial inclusion, with specific attention to the marginal inner areas and the system of the smaller ancient villages [33].

Even in cities undergoing renewal processes, historic urban fabrics suffer the effects of new property interests, reducing the network of social relations and the original inhabitants' sense of belonging. In these cases, the reinforcement of public support measures inspired by the green economy and of great perceptive impact, such as green roofs on a neighborhood-scale, would foster the rise of a new sense of community and an "environmental identity" based on the conviction of the citizens that they are contributing actively and personally to the "ecological transition".

With reference to public support for the building sector, on the one hand, this "green deal" [34] outlines significant prospects for the city, territory, mobility, etc. [35,36] in the wave of emerging lifestyles and new living space conceptions [37,38]; on the other hand, it raises doubts and concerns about the inflationary pressures and distorting effects in the construction sector and about the redistributive effects between conflicting economic sectors, between "state and society" and between the social system and environment [39,40] due to the huge amount of waste produced by renovations.

Outlining an optimistic perspective, this research identifies the green roof practice as the conceptual, behavioral and operational prospect of multiple value matrices [41,42], converging to the dialectic between individual interests and the social preference system concerning the unexpressed urban potential [43,44].

Such a complexity does not make it easier for the decision makers implementing unitary policies on an urban-scale to trigger both social and external effects, such as variety and scale economies [45] and economies that are partly external to each urban unit (building or block) but internal to the neighborhood [46], in typical organization and specialization economies [47].

The above concerns delimitate the main point of this research, which focuses on the creation and application of a neighborhood-scale strategic planning model for the identification of the best layout of roof-use options.

As for the method, some contributions in the literature fit the perspective of social communication, which this paper evokes in supporting a reform of neighborhood identity.

Some contributions concern the involvement of the stakeholders through a participatory approach aimed at sharing information and decisions [48,49]. Some other ones concern the operational and involvement tools, such as a "man–machine interface", allowing decision makers and stakeholders to share the results from the "if, . . . then" functions; this approach allows one to explore the possibilities to come up with alternative scenarios that are all internally coherent although sometimes very different from each other [10,12].

As for the topic, the intermediate architectural–urban scale, the specific reference to the roof reuse [50] and the involvement of valuation criteria explained by quality–quantitative and monetary indicators make the proposed analytic approach significantly different from the ones which Voskamp et al. [51], Gertman et al. [52] and especially Rohani and Ma [53], in their extensive and accurate literature review, compared, analyzing planning and programming on architectural and urban scales.

The operational context selected is a historic neighborhood characterized by a set of criticalities and potentials due to its location and history and the transformation process the city is currently going through.

The neighborhood is nowadays at risk of losing its original identity due to both the recent replacement and transformation of some historic buildings, and above all, the potential gentrification process in the wake of the exponential growth of tourist and real estate interests in Ortigia, the old part of the historic center of Syracuse. By means of the creation of an "environmental brand" of the Borgata di Santa Lucia, the original neighborhood identity can turn into an environmental identity within a consistent and efficient as well as fair public funding program fostering the Green Turn.

The relationship between the valuation and project is not free from uncertainties due to the fundamental differences in characterizing them concerning function and prospects:

- valuation validates an "action" (a project option) with reference to some value attributes, the contents of the value function; from the perspective of valuation, the project needs to match some prefixed requirements;
- the project aims at innovating functions, language and identity by preserving their consistency; the project creates a "surplus of shape" by recognizing and at the same time overcoming the usual rules; from the project perspective, valuation must explain and measure such a surplus.

1.3. Contents and Scopes

The research is part of the studies on detailed planning in historic city centers and concerns the creation of an operational model, on a neighborhood-scale, for the representation, evaluation and strategic planning [54] of the uses of roofing that are most appropriate for the purposes of protection and enhancement of the urban landscape, mitigation of the effects of climate change [55], energy efficiency of buildings and general cost-effectiveness [56] in the use of public funding provided by the European Union policies currently in force.

The application context is a large part of the building–urban fabric of the "Borgata di Santa Lucia in Syracuse" (Italy), consisting of 1075 buildings grouped in 104 blocks.

The proposed model prefigures the hypothesis that the local administration intends to implement a system of rules for the sustainable use of roofs according to a unitary and overall design and to achieve, through it, differentiated objectives according to a logic of optimization.

The detailed planning regulations for this part of the historic center, with reference to roofs, set limits and conditions on the installation of renewable energy systems and on vertical extensions above existing buildings, in addition to those that more generally concern the granting of building permits in compliance with the types of works prescribed.

These limits and conditions, together with technological, economic and environmental aspects, constitute the constraints that the planning model uses to define the different layouts from which specific evaluation functions help to choose the best one.

The research comprises three integrated and interacting phases:

- the first, mainly descriptive, consists in the investigation of the historical and urban profile of the Borgata di Santa Lucia and, subsequently, in the systematic and orderly collection of data on the scale of the Building Unit (BU) and in the transformation of the data, through the construction of synthetic indices, into information units aimed at the definition of the valuation profile of each BU in relation to the operational purposes of the model application;
- the second, typically methodological, consists in the logical coordination of the different operational phases and in the definition of the calculation functions necessary to outline the intervention strategies, evaluate and compare them and choose the best one;
- the third, operational, involves the formation of the strategies in groups of 20, with each group formed based on one of five different approaches prefigured by implementing specific logical conditions; finally, all strategies were evaluated against the four value matrices whose terms of trade-off and convergence were indicated.

2. Materials

2.1. The "Borgata di Santa Lucia" in Syracuse

2.1.1. Historical Background and Urban Development

The "Borgata di Santa Lucia" (Figure 1) is the most recent part of the historic center of Syracuse; until the 17th century, it remained within a predominantly agricultural context. consisting of small parcels of land cultivated by farmers who resided in Ortigia.

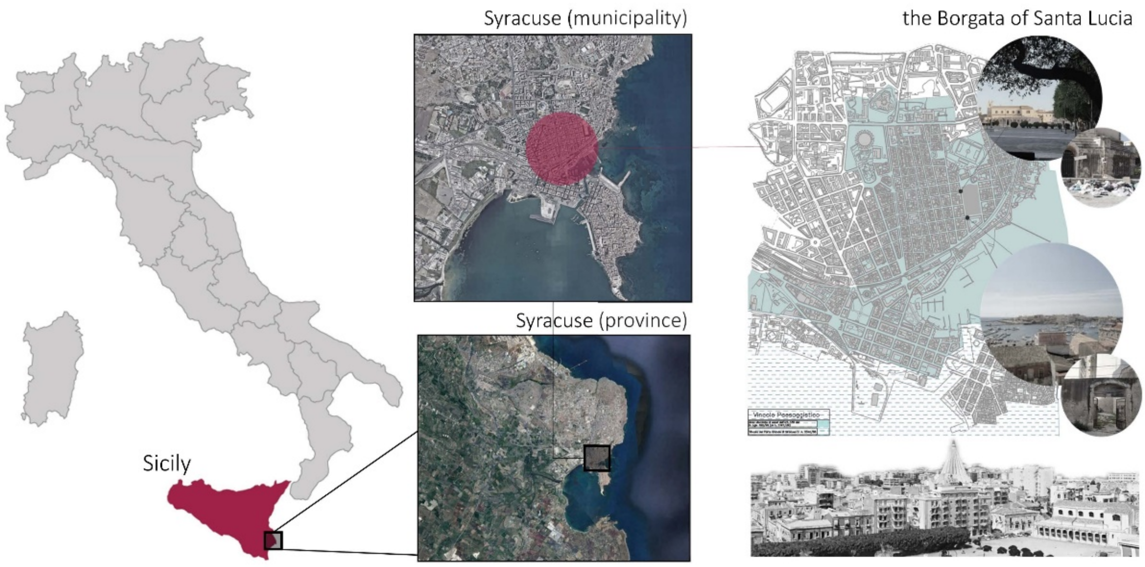

Figure 1. Territorial framework of the Borgata di Santa Lucia neighborhood in Syracuse.

The latter is the oldest part of the city, founded during the first Greek colonization on an islet, today connected to the mainland by two bridges. During the second half of the 19th century, the municipality began a process of expansion, due to the rapid increase in population, which caused serious health and housing problems, by favoring the transfer of part of the population from the islet to the Borgata [57].

The urban development of the Borgata district began immediately after the demolition of the walls of Ortigia, around 1865.

In 1886, the first buildings were built: the first nucleus, planned by the engineer Scrofani, was made up of small affordable houses to be sold to farmers, fishermen and carters.

Subsequently, the area was affected by intense building activity, carried out through private subdivisions, as shown by deeds in the Notarial Archives of Syracuse. The growth process and the progressive saturation within the blocks and lots produced, over time, a stratification that has diverse levels of consolidation and densification in the different parts of the Borgata.

The development of the building process displays a clear relationship between settlement patterns and building types, as well as between the shape and size of the lots.

Until the beginning of the 20th century, construction only concerned the ground floors, and the upper floors were built only subsequently. This growth led, in some cases, to the occupation of the courtyards, giving rise to rather significant changes to the facades.

The building fabric of the Borgata is therefore the result of a progressive sedimentation of building units within a consolidated urban grid and according to binding type–morphological relationships, that only in the last 50 years have been interrupted by the construction of tower buildings, the replacement of various original houses and the contemporary completion of the urban fabric.

2.1.2. The Borgata Today

Today, the Borgata is characterized by some tensions between the unity of the settlement principle and building disorder phenomena and between the presence of a good architectural level and widespread functional, technological, performance and maintenance deficiencies that do not encourage settling, namely of young families.

The link between the Borgata and the city dates back to the history of the first territorial plans of Syracuse, and the growth of the Borgata itself was due to the fact that it was identified as an urban unit with a strong identity, potentially capable of expressing the values of urban centrality. This study was based on the belief that the reaffirmation of the lost urban centrality depends on the convergence of the physical–functional recovery of the building heritage and the recovery of the neighborhood identity. This methodological and operational proposal summarizes these two conditions by identifying the sustainable reuse of roofs as the interface between the needs of urban capital [58] and the demands and, therefore, between the matrices of practical value and symbolic value [59].

2.1.3. Rules: The Plan

The General Town Plan currently in force, approved on 3 August 2007 (Official Gazette of the Sicilian Region, 28 September 2007), places the "Borgata di Santa Lucia" in Homogeneous Territorial Zone B (B1.2), distinguishing fabrics of consolidated environmental value (the part following the development of the Umbertino neighborhood, built since 1885 and subsequently subject to the Cristin 1917 Town Plan) and fabrics characterized by the presence of non-homogeneous building types and prevalently residential uses.

Detailed regulations rule the redevelopment of the consolidated building fabrics of environmental value [60], aiming at preserving their morphological and settlement rules and protecting the typological and architectural features of the buildings. These regulations recognize the type-morphological characteristics, architectural quality, state of conservation and current uses of each building and concerns, for each building unit, the different types of intervention and admissible uses according to their typological and architectural characteristics.

The regulations governing the energy sources of existing buildings require that:

- solar systems may only be installed on flat roofs or terraces and must not be visible from public spaces;
- heat pumps may only be installed in the building courtyards, exclusively on the ground floor, or in special technical rooms; the façade of the building must not in any way be used for the installation of motor bodies or cables.

2.1.4. The Building Fabric Critical Analysis: Denotation and Connotation

The information base that supported the creation of the proposed valuation-programming model [61,62] consists of a database (Figure 2) containing, as records, 1075 Building Units (BU) and, as fields, all the dimensional, constructive, typological, technological, morphological, functional, architectural and historical–testimonial characteristics necessary for the implementation of the programming functions of the sustainable uses of the roofs of the BUs.

block	unit				x	y
1	1	+ 150 3 m p f >0.25	375	+ 150	125.796	85.509
1	2	+ 150 2 m p f >0.25	296	+ 150	151.319	87.082
1	3	50-150 2 m p f <0.25	138	50-150	168.036	88.803
1	4	50-150 1 m EdB f <0.25	116	50-150	176.859	91.383
1	5	-100 1 m EdB t <0.25	78	-100	183.129	92.208
1	6	-100 3 c EdB t <0.25	99	-100	189.062	92.942
1	7	+ 150 >=4 c EdB t <0.25	155	+ 150	199.651	94.004
1	8	50-150 1 c EdB f <0.25	121	50-150	210.059	96.842
1	9	+ 150 3 m p f >0.25	264	+ 150	226.487	98.981
1	10	+ 150 >=4 c altro t <0.25	182	+ 150	222.928	114.157
1	11	+ 150 >=4 c p f <0.25	211	+ 150	217.662	124.952
1	12	+ 150 1 m EdB f >0.25	316	+ 150	208.359	134.345
1	13	+ 150 3 m p f <0.25	280	+ 150	196.411	117.369
1	14	50-150 2 c EdB f <0.25	127	50-150	188.22	118.235
1	15	-100 3 m p t <0.25	84	-100	184.397	116.221
1	16	-100 1 m EdB f <0.25	71	-100	179.382	118.156
1	17	+ 150 3 m EdB f <0.25	230	+ 150	175.179	111.601
1	18	+ 150 2 m EdB f <0.25	335	+ 150	164.578	107.479
1	19	+ 150 2 m EdB f <0.25	335	+ 150	133.913	100.503
1	20	-100 2 m p f <0.25	62	-100	146.688	103.975
1	21	-100 >=4 c p t <0.25	84	-100	126.911	99.333
1	22	-100 2 m p t >0.25	84	-100	115.505	95.222
2	23	+ 150 2 m PA f >0.25	322	+ 150	107.111	117.292
2	24	50-150 1 m EdB t <0.25	148	50-150	119.72	127.772
2	25	50-150 2 c EdB f <0.25	105	50-150	129.985	128.097
2	26	+ 150 2 m p f >0.25	201	+ 150	138.654	131.881
2	27	+ 150 2 m p f >0.25	211	+ 150	137.325	146.102
2	28	+ 150 2 m EdB f >0.25	398	+ 150	131.197	159.82
2	29	-100 1 m EdB f <0.25	52	-100	116.237	159.089
104	1074	+ 150 2 c EdB t >0.25	174	+ 150	797.601	652.556
104	1075	+ 150 1 c altro f >0.25	182	+ 150	802.556	632.567

Figure 2. Excerpt from the database of the 1075 building units studied.

A first interpretation of the collected data revealed an urban landscape characterized by a certain type-morphological and image coherence. The architectural units are prevalently small in size: the standard values of the footprint area is 167 sq. m (Figure 3a), and the standard exposed surface area of the façades is 163 sq. m.

A total of 297 BUs out of the 10,775 surveyed are ground floor houses, 432 have one more story, 235 consist of three stories and 64 have four stories, and the remaining 47 are condominium buildings of recent construction with more than four stories (Figure 3b), which do not fit in well with the context. The estimated construction periods are the 1850–1900 range for 34 BUs, 1900–1945 for 256 BUs, 1945–1970 for 328 BUs, 1970–1990 for 324 Bus and 1990 to present for 133 BUs.

Six building types were identified (Figure 4):

- Major Mansions
- Minor Mansions
- Typical Basic Buildings
- Dethatched Buildings
- High Rise Buildings
- Row Houses
- Block Buildings

A total of 751 out of 1075 BUs are classified as basic construction, 212 are Minor Mansions, 20 are Major Mansions and 92 are distributed among the remaining types (Figure 3c).

As for the roofing system, three main typologies were recognized for the purposes of this study, assorted as follows: 390 BUs have pitched roofing, 347 ones have terrace roofing and 338 have mixed or terrace and canopy roofing (Figure 3d).

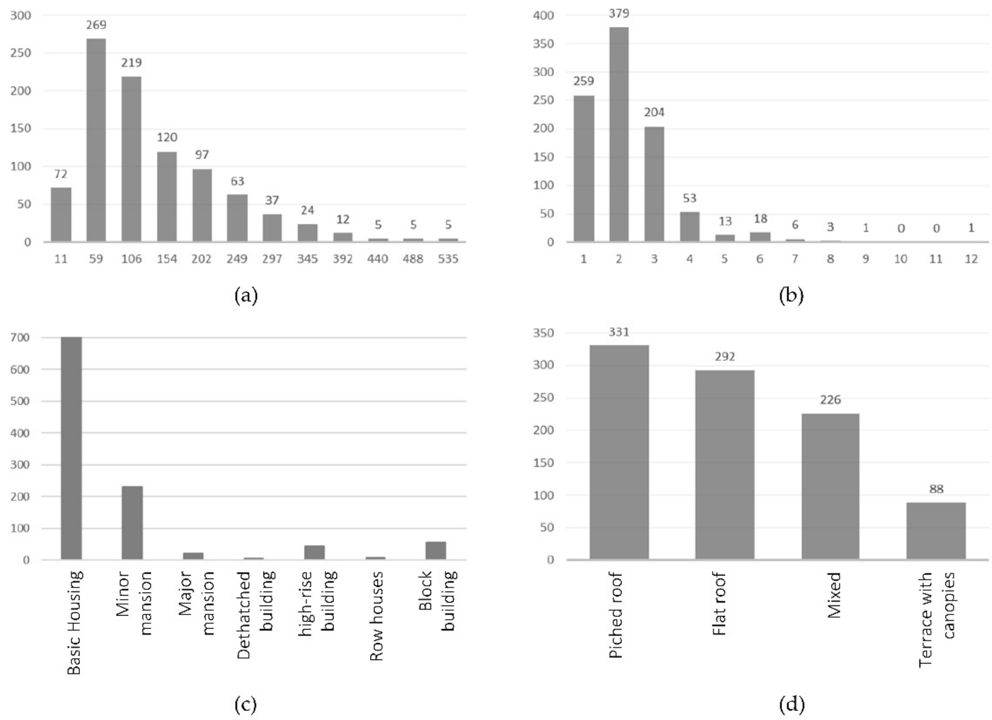

Figure 3. Summary of some of the main dimensional and typological characteristics of the Borgata: (**a**) footprint area; (**b**) number of stories; (**c**) building type; (**d**) roofing type.

Figure 4. Identified building types.

In order to support the decision-making process by means of an easier "man–machine" interaction, a GIS (Geographic Information System) platform was created for spatial analyses and mappings of all the characteristics of higher landscape value [63]. Throughout the whole cognitive process, systematic graphical queries were carried out, thus favoring the creation of a synoptic awareness of the multiple qualities of the whole urban building context and the referability of the numerical findings to the basic information (Figure 5).

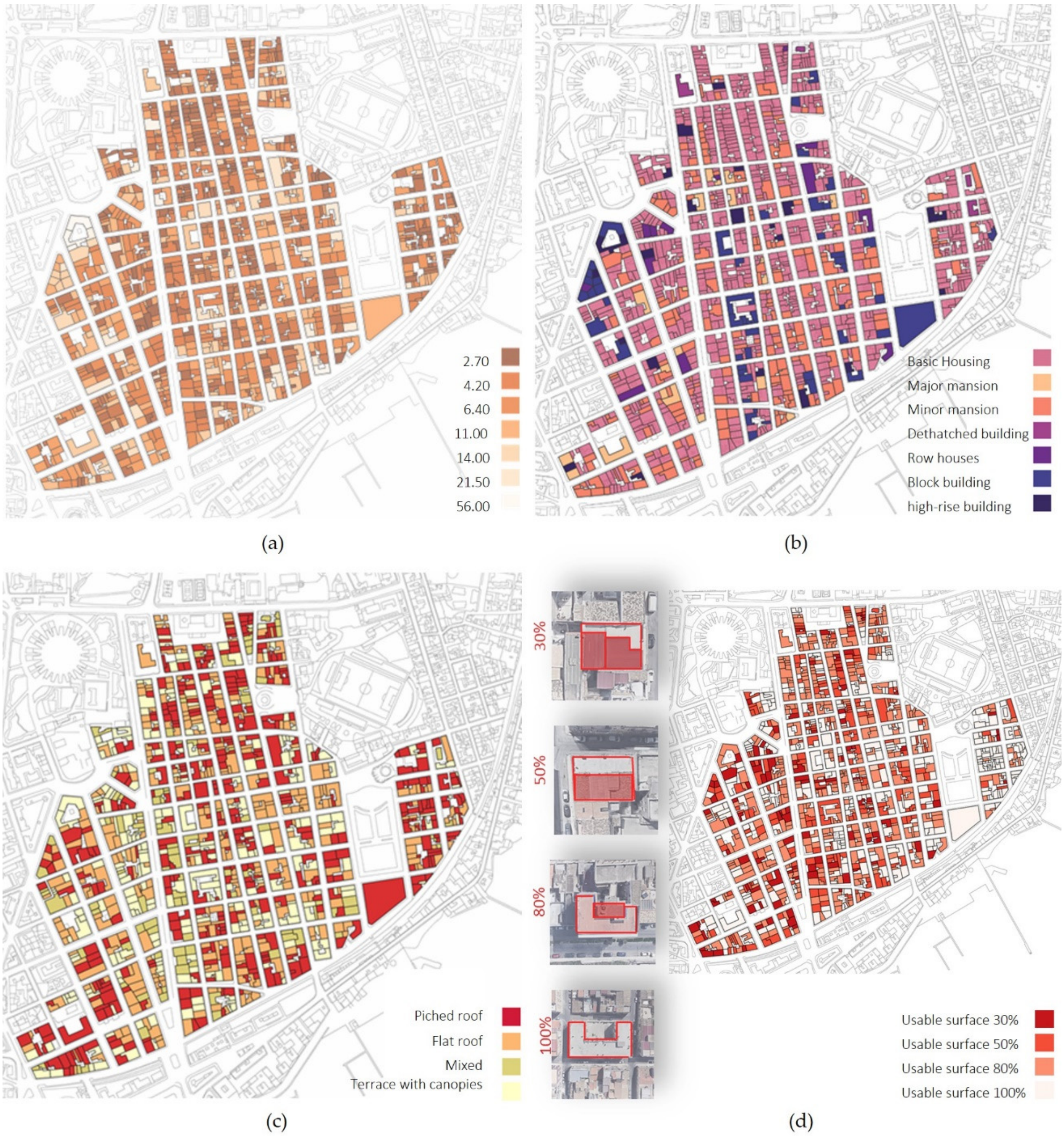

Figure 5. Example mapping of some characteristics of surveyed BUs: (**a**) number of floors; (**b**) type of building; (**c**) type of roof; (**d**) degree of roof fragmentation.

2.2. Green Roof

2.2.1. Why Green

The practice of green roofs [64–75] has recently reached high levels of performance thanks to the development of highly advanced design techniques in the field of design due to unquestionable functional; environmental; energy; aesthetic and, on an urban scale, even landscape advantages; according to the purposes of this paper, the green roof practice itself could help carry out a real reform of the urban identity of a historic district with a strong unexpressed human and social potential [76].

This new way of integrating the natural element into the architectonic form has found its *raison d'être* in both functional and technical–constructive terms since the early 20th century, in Le Corbusier's revolutionary vision of the roof garden as one of the five points of architecture. The more contemporary energy–environmental perspective [77,78] has introduced the notion of "green roofs", within the framework of naturalistic engineering [79], extending the natural element even to the greening of façades. In this sense the building object is transformed into an architectural organism that incorporates the living component not only in the design, but in the very functioning of the architecture.

This same organicist perspective has also accompanied the evolution of town planning, since the growth of the climatic disorder has amplified calamitous phenomena and hydrogeological disruptions due to the systematic sealing of soils and the destruction of natural safeguards against landslides and floods. Nowadays, even small towns are not exempt from the problems of large settlements, such as air and groundwater pollution, lack of green areas, excessive concreting, road traffic problems, clogging of sewage networks, impoverishment and imbalance of the flora and fauna in man-made spaces, resulting in less resistance against adversity and disease.

The integration of green roof technologies and practices into the process of sustainable redevelopment of historic urban districts proposed here prefigures a new urban form that combines natural, functional and symbolic aspects so that the very identity of the neighborhood is redefined according to a new contemporary vision.

2.2.2. Rules: Green Roof

A green roof is a complex system that adapts to the characteristics of the location where the roof is built and, thus, to the climate and geographical conditions of that location; to the state of the roof that is to be modified in the case of an existing building and to the energy, functional and perceptual requirements.

The 2007 Italian Standard UNI 11235 [80,81] provides the following definitions of green roofs:

- extensive green roof: a system that uses plant species that are able to adapt and develop in the environmental conditions in which they are placed, thus requiring minimal maintenance;
- intensive green roof: a system using plant species able to adapt and develop in the environmental conditions in which they are placed, with the necessary medium for high intensity maintenance, depending on the plant species associations.

UNI 11235 is a performance standard and defines the minimum requirements for each of the elements used in the system (Figure 6). It also specifies which are the primary elements, i.e., those that must always be present:

- Load-bearing element
- Watertight element
- Root protection element
- Mechanical protection element
- Draining layer
- Water storage layer
- Filter element
- Cultivation layer
- Vegetation layer

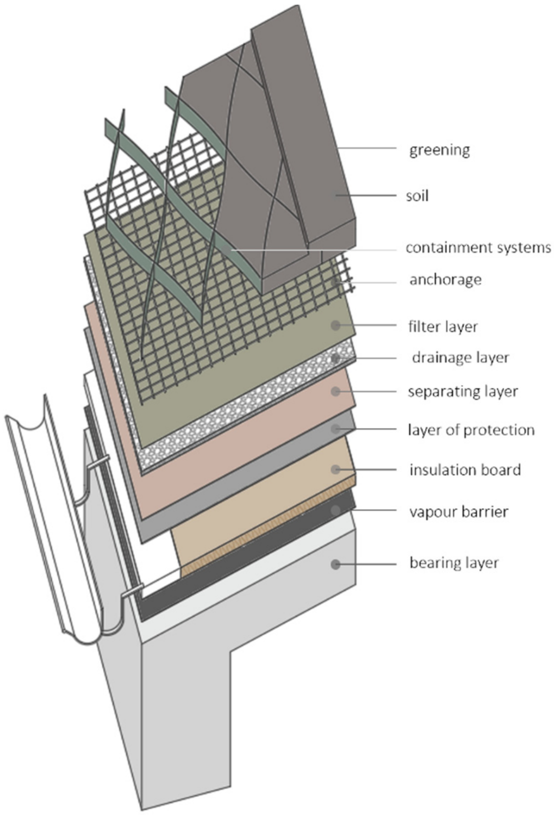

Figure 6. Stratigraphy system of a green roof.

The standard also classifies green roofs according to:

- Geometry: Standard UNI 8627-1:2019 defines two possible functional schemes of roofing systems, distinguishing between flat and pitched roofs. Three possible functional schemes are identified: horizontal roofs, characterized by a 1% pitch to ensure the effective drainage of rainwater; sub-horizontal roofs, with a pitch between 1% and 5%; pitched roofs, with a pitch greater than 5%. The cost of construction and maintenance increases as the pitch increases;
- Type of installation: Extensive green roofs are blankets that use plant species that can easily adapt to environmental conditions, with high reproduction efficiency and resistance to the water and thermal stresses to which they are exposed. They therefore require a low level of maintenance. On the other hand, the plant species used in intensive green roofs are characterized by organic, deeper layers of cultivation and therefore require a higher level of maintenance and a flat, horizontal layout;
- Accessibility/accessibility: this classification consists of 6 classes: roofing accessible for maintenance work only; roofing accessible for maintenance work pertaining to both functional layers and installed systems; roofing accessible to pedestrians (max kN/m^2); roofing accessible to pedestrians and light vehicles (<2 t); roofing accessible to pedestrian and vehicular circulation; intensive roofing, capable of withstanding the relevant mechanical and chemical stresses.

The Ministry of the Environment provides indications for exemplary design and implementation, not only for the intrinsic properties of the green roof system, but taking into consideration the relationship with the type of building, the location and the expected performance. From this point of view, the guidelines complete UNI 11235 with indications addressed to the designer to transform green roofs from a "standard" to a "customized" solution.

2.3. Blue Roof

The preliminary checks carried out to assess the feasibility of the “Green project” already revealed concern about the high number of small buildings with fragmented and mixed roofs unsuitable for the green purpose.

Integrating the green roof with the installation of photovoltaics systems, where possible, proved to be a solution that would not only allow the involvement of almost all the building units in the project, but also a significant cost-effectiveness of the investment [82].

The criteria for the provision of incentives to support private initiatives towards the “green perspective” are defined within the institutional, financial and legal framework outlined by Legislative Decree 28/2011 [83] for the achievement of the objectives up to 2020 on energy from renewable sources. The regulatory framework concerning the safety of the installation and the proper functioning of the system is defined by the 2018 CEI EN 62446-1 standard [84].

2.4. Green-Blue: A Further Possibility

Roof gardens and photovoltaic systems are often wrongly considered to be antithetical solutions [85], despite the fact that, in reality, the optimal location for a photovoltaic system is on green ground and not on a layer of concrete or on an insulated layer.

Furthermore, photovoltaic panels are usually laid at an angle of 30 degrees, thus creating shaded areas useful for the development of vegetation and diversity. Finally, the coexistence of the two uses does not give rise to any increase in the maintenance costs of the photovoltaic panels, which are in no way affected by the presence of vegetation beneath them [86].

On the contrary, green roof vegetation improves the performance of the photovoltaic system, because it regulates its temperature in the event of overheating, since the performance of the photovoltaic system is reduced by 5% for every 10 °C above (or below) the optimum temperature (25 °C), and the maximum temperature of a green roof is 25–30 °C.

2.5. Grey Roof

Furthermore, where envisaged by the detailed plan, the model manages the option of an increase in building volume but, according to the purposes of this research, under the condition of the greening of the new roof.

The detailed plan assumes the increase in building volume as a vehicle for the repopulation of the Borgata, together with the objectives of the placement of collective facilities in the remaining free areas, the complexification of the functional mix, the improvement of living comfort, and the attractiveness and improvement of life in the neighborhood by means of the construction of facilities of general interest.

However, a Masterplan founded on judgements not internally consistent can create some contradictions. The planning model for the re-use of roofs proposed here has highlighted many situations of conflict between the demands of conservation and the needs for transformation, such as, for example, the case of many historic buildings, including major mansions, which have been included in the “integrated vertical extension” category.

The model resolves this conflict by accepting this possibility only if it is justified within an internally coherent overall strategy, that is best from the point of view of multiple evaluation criteria, including the economic one, in terms of real estate valorization [87,88] but appropriately compared to the other criteria by means of an appropriate weight system.

3. Method

3.1. The Conceptual Model

The subject of this research is the creation of a “generative model” [89] for the representation, evaluation and strategic planning of the most efficient and effective strategy for the roofs re-use on a neighborhood-scale, inspired by the “green revolution” implied by the ecological transition of policies, economies and cities [90–93].

The basic idea is to provide an easy-to-query tool, which, based on a large database and a rigorous valuation model, associates each BU with a specific Re-use roof Work Type (RWT), according to a set of preliminary conditions, which define the strategic profile of the intervention as a whole.

The model coordinates the three main cognitive areas of Analysis, Evaluation and Project (Figure 7), throughout a decision-making process aimed at outlining the best intervention strategy [94–96]:

- The Analysis provides a detailed description and characterization of each BU according to different attributes concerning both Evaluation and Project, within the general perspective of a semiotic valuation approach [97,98]:
    - Concerning the Evaluation, the Attributes are relevant, because they outline the Aptitude of the roofs to more or less sustainable uses;
    - Concerning the Project, the Constraints are relevant, because their progressive release gradually enables more transformative (from green to blue or grey) RWTs;
- The Evaluation assumes as its basic raw material of "what actually matters" in the dialectics between the green–natural and the urban–social instances; as a consequence, the evaluation works on both the building and urban scales:
    - on a building-scale ("Green matters!"), some "Object Aspects" (building sizes, distances, typologies and so on) enable the Sorting functions by means of which the Green, Blue or Grey RWT is attributed to each BU; at this stage, due to possible multiple correspondences between the BU profile and the RWT, evaluation may provide ambiguous sorting of the Bus; the next Project (decision-making) functions solve this ambiguity as later explained;
    - when projected on an Urban District scale ("City matters!"), the evaluation functions are aimed at the final selection of the best strategy according to the above-mentioned axiological matrices by means of a Multi-Attribute Value Theory tool;
- The project concerns the generation of overall Strategies according to two different Modalities of releasing the Constraints. These modalities differ in a) the starting Strategy and b) how to resolve ambiguities in the sorting of BUs between RWTs. In fact, due to the multiple sorting of the same BU between more than one RWT, four further different Approaches have been applied in Modality 2:
    - Modality 1, inspired by a general prospect of sustainability, generates the first 20 strategies according to Approach 0, which assumes, as the starting Strategy, the maximum development of green roofs and resolves the above-mentioned ambiguous sorting by choosing the Green option;
    - Modality 2 arranges a further 80 strategies, assuming, as starting Strategy 0, Option ("do nothing") and solving the ambiguous sorting according to four further approaches: Approach 1 solves the multiple-sorting by choosing green; Approach 2, choosing green–blue; Approach 3, choosing blue; Approach 4, choosing grey.

Such a method applies the principles of "generative grammar", considering the possibilities of "a limited set of rules to give rise to a family of theoretically unlimited, but still consistent and recognizable, combinations, with respect to which compatible, appropriate and responsible transformations can be created".

The compatibility between the different strategies is guaranteed by the "grammatical constraint", that is the unitary set of rules that the decision maker must respect for generating each strategy.

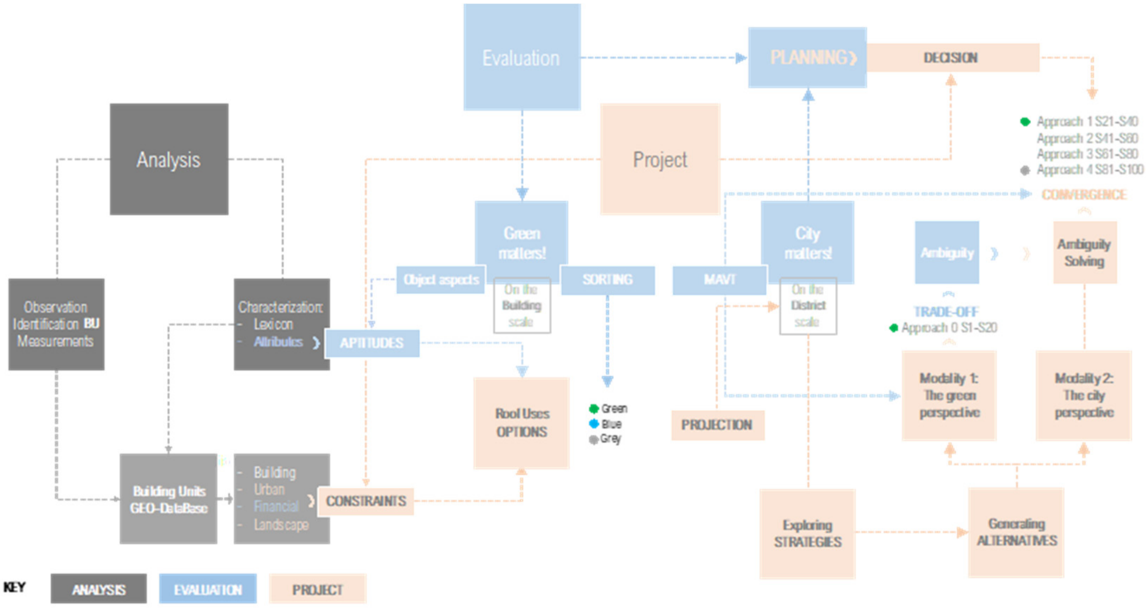

Figure 7. Conceptual model of the strategic programming approach.

Once all strategies have been outlined, the multi-criteria model defines the trade-off and convergence functions between the four "axiological matrices" (landscape, economic, energy–environmental and identity) by comparing the 20 strategies of each of the five different approaches described.

It is evident that the functional and economic matrix are convergent, because the better the buildings "work", the higher their real estate value [99–105] and the lower their maintenance and redevelopment costs.

Otherwise, a "natural" conflict (trade-off) emerges between identity (or landscape) and the economic matrix, because if the profitability of the interventions increases, due to the increase in volume of the overall urban fabric, the context will be affected in its original identity values.

The awareness of such a relation is due to the abstraction of the concrete qualities of the buildings through the numerical representation of their characteristics; as a result, the management of this standardized information through a unified lexicon is a "simplification without loss of information" [106], which allows one to compare different goods from the point of view of a multiplicity of characteristics, as well as to process large amounts of data.

The formation of automated processes based on the "if–then" logic allows one to expand and give meaning to the information contained in the simple description by creating indices, relationships, evaluations and solutions (the strategies) and by providing the evaluator/decision maker with the tool to maximize the preference function by creating (not just choosing) the best strategy. More specifically, once established, for example, for the Green–Blue–Gray preference order:

1. if from the point of view of the "main necessary conditions" a building admits green roofing, then the algorithm assigns Green RWT and chooses, on the basis of the "secondary conditions", the green roof system A1 (Pitched roof extensive greening,), Ba1 Flat roof not practicable extensive greening) or Bb (Flat roof practicable);
2. if not, the algorithm verifies whether the conditions for Blue RWT are met, and if so, it associates the type compatible with pitched or flat roofing;
3. if not, the algorithm checks whether the DP permits the vertical extension for that building and assigns the Gray RWT to the extent and under the conditions permitted.

This order of Green–Blue–Gray preference can be modified according to the approach one chooses to take into account the way in which the local government interprets sustainability perspectives within its urban policy guidelines (Figure 8).

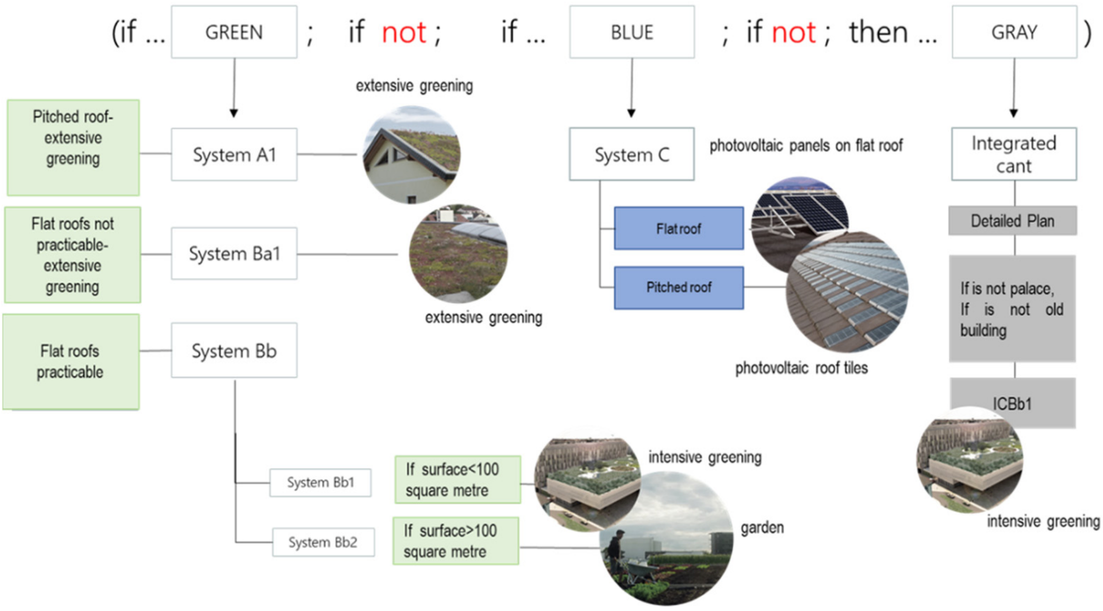

Figure 8. Flowchart of the process for attributing the RWT to the single BUs.

In the perspective of a generative strategic planning model, some concepts of semiotics and generative grammar support the creation of the semantics and metrics common to quantitative–monetary and qualitative evaluations.

Therefore, the building unit is assumed as a combination of:

- The Physical Reference, which is the building as a physical object represented in the evaluation/project communication system through a set of characteristics;
- The Signifier, which means the above characteristics to which a value judgement is attributed;
- The Signified, which is the content of the value judgement.

The urban context plays the syntactic functions of a semantic chain, within which the value functions (Signification processes) arise, consolidate and change. Finally, the recursive feedback of results on rules makes the procedure described in the three areas of Analysis, Evaluation and Project perfectly circular and consistent with the concept of "revisable truth" [106].

3.2. The Programming Model

The model for the creation of the strategies associates each BU with an RWT, combining different and converging intentions (social mind) with the identity profile of the urban social context (local community feeling). Their synthesis defines the three main prospects: Green, sustainability-oriented, through the implementation of green roofs; Blue, energy efficiency-oriented, through the integration of photovoltaic plants; Gray, real estate-oriented, through the increase in building volume as allowed by the Detailed Plan.

3.2.1. Green

The application of each of the four RWTs of the Green prospect (extensive for pitched roofs A1, extensive for flat roofs Ba1, intensive Bb2, mixed B2) to each BU depends on the following:

- Main or necessary conditions:
    a. Minimum surface area: the algorithm allocates a BU to a green roof RWT if the roof size is bigger than a minimum hypothesized standard size: the bigger the size, the lower the number of green roofs.
    b. Degree of fragmentation: it is a three-degree scale attribute assigned to each BU by direct observation: the higher the fragmentation, the smaller the green roofs.

c. Geometry: the ratio of the length by the width of the roof affects the feasibility and cost of the green roof: the higher the ratio, the smaller the number of green roofs.
d. Building type: simpler building types make it easier to realize green roofs: the simpler the type that is deemed suitable, the many more green roofs.

- Secondary or ancillary conditions:
  a. Number of floors: a lower number of stories makes the green roof more visible from public spaces, so that lower buildings have priority for the allocation of a green roof.
  b. Characteristics of the roof (referring to RWT Bb2):
  c. Accessibility of the roof; priority is given to buildings with easy access to the roof, which facilitates maintenance, cultivation and enjoyment.
  d. Age of the building: older buildings are more at risk in terms of structural strength and, therefore, less suitable for green roofs.
  e. Maintenance degree of the roof: a lower maintenance degree claims renovation works, encouraging a new and innovative use of the roof.

3.2.2. Blue

The application of one of the two RWTs of the Blue perspective [107–110] (flat roof photovoltaic panels C1; integrated photovoltaic tile systems C2) to each BU depends on the following:

- Main or necessary conditions:
  a. Visibility of the roof: visibility of the photovoltaic panels from public spaces is due to the height of the building and to the width of the street/square in front of it: a greater visibility requires panels to be set back from the façade of the building, thus reducing the usable area and possibly discouraging installation.
  b. Shading: a higher degree of roof shading reduces the performance of the panels, making the investment less cost-effective.
- Secondary or ancillary conditions:
  a. Roof characteristics: fragmentation, scarce accessibility, irregular geometry, height differences and presence of canopies make canopies make the installation and maintenance of the panels more difficult.
  b. Building type: the basic dwelling types are more suitable for blue roofs than palaces due to landscape matters.
  c. Surface area of the roof: even small areas are easily used for the installation of photovoltaic panels, and very large ones would not be fully utilized given the low tariffs applied to surplus energy produced.
  d. width of the main façade: although not considered by the DP in force, the landscape impact of the blue roof visible from private areas (the upper floors of neighboring building) is taken into account by this model; therefore, BUs with roof surfaces further back from the eaves line are favored.

If a BU is associated with both of the above RWTs, the model selects Green–Blue, which is the combination of green roofs and photovoltaics on the basis of a subordinate characteristic, the roof surface area.

3.2.3. Grey

The application of the RWT realizing the Grey perspective (integrated increase in building volume) to each EU depends on the following:

- Main or necessary conditions:
  a. Prescription of the Detailed Plan (DP); this opportunity is limited just to the building allowed by the DP.

b. Building type; the DP excludes the possibility of vertical extension only for the most valuable palace typology. On the merits, the model adopts a more restrictive hypothesis by admitting this possibility only for the less valuable types; only in the hypothesis of maximum expansion of this RWT does the model consider the possibility of allowing extensions to the medium value palaces as well, complying with the DP.

- Secondary or ancillary conditions:
  a. Surface: just the smaller BU should be allowed to increase their volume;
  b. Building maintenance: a very low maintenance degree could encourage a general and systematic plan of renovation with volume increase and building energy retrofit.

Due to the constraints set up, strategy number 1 turns out to be the strategy that most emphasizes the Green roof prospect, while Blue roofs are significantly present and start growing from strategy 12 on; the same can be observed for Grey roofs, but to a lower extent, starting from strategy 16; the last strategy is characterized by the clear prevalence of photovoltaic panels and the integrated increase in building volume. (Figure 9).

Figure 9. Example mapping of the 20 strategies of Approach 0.

3.3. Evaluation Model

3.3.1. Multiple Criteria Analysis

As mentioned, evaluation supports the planning process both on a building-scale (BUs Sorting—BUsSort) and on a neighborhood-scale (Strategies Ranking—StrRank). In both cases, heterogeneous value attributes belonging to different motivational matrices are coordinated, so that the evaluation process refers to multiple criteria.

Both BUsSort and StrRank are carried out through a Multiple Criteria Analysis model based on the Multi-Attribute Value Theory (MAVT) [111,112], an additive-type model that uses value functions to normalize the multiple performances of both the analyzed BUs and the outlined Strategies within a range of standard values. Quadrilinear normalization scales were used for BUsSort and bilinear ones for StrRank:

- The quadrilinear functions take, as reference values, the minimum, the maximum and the three quartiles of the performance measurements of the 1075 BUs against each criterion;
- The bilinear functions take as reference values the minimum, maximum and average performance measures that the 20 approach strategies take with respect to each of the indicators of the four neighborhood sustainability matrices.

With regard to the choice of the best strategy and in view of the operational consolidation of the relationship between evaluation and project, the consideration of multiple criteria broadens the very meaning of the 'best option' [113,114], which is really the best only once the weighting system of the criteria [115] has been established.

Accordingly, in both cases (BUsSort and StrRank), each criterion was associated with a weight measuring its relative importance compared to others of the same rank and for all levels of the criteria hierarchy.

With this procedure, the construction of the best intervention strategy stands as a constant, progressive and potentially unlimited process of querying a database [116], whose combinations allow for the recursive construction of 'ever-new' different forms. The latter retain their internal coherence due to the inseparable reference to an underlying system of rules that is not modified.

This multiple criteria evaluation model supports the formation of each strategy by providing, in real time, a measure of its ability to respond to the requests of the following four axiological matrices:

- the landscape matrix refers to the diffusion of the practice of green roofing as an index of the broadest sharing of a sustainability perspective; other aspects supporting this perspective are the perceptibility of green roofs from public spaces, which depends on the height of the building and the type of roof (green pitched roofs on lower floors are more visible);
- the identity matrix refers to the type of greening (lawn or Sedum on a sloping roof or roof garden on a flat roof) and the greening attitude of the building type;
- the energy–environmental matrix refers to the energy from renewable sources that can potentially be produced and to the sequestration rate of greenhouse gases;
- the economic matrix refers to (a) the real estate advantage connected to the increase in the building volume, as well as to the net benefit of the investment in photovoltaic systems and to (b) the disadvantage connected to the costs of green roofs, not repaid by the small associated energy savings.

Two in-depth analyses were made for the calculation of costs and for the calculation of the surfaces of the flat roofs intended for photovoltaic exploitation.

3.3.2. Cost Calculation

The cost analysis was carried out based on both the price lists published by leading companies in the sector, with regards to some of the items on specific works and components, and the 2019 regional price list of public works in the Sicilian Region [117]. with respect to the standard works for the implementation of green roofs.

For each system, the layout of the related work classes was defined, and the related elementary components were identified.

To compare the different works of the same type (extensive, intensive or mixed), the construction cost (not dependent on the type of green roof) was distinguished from both the costs of the stratigraphy (insulation and greening) and the works for the rainwater disposal system (replacement, maintenance or recovery).

The list of works in shown by groups of works; the identification code of the item; the code of the item; the RW; the unit of measurement and the components of the calculation of the technical cost, i.e., the unit price of the production factors (capital and labor) and the necessary materials, and finally the total unit price (Table 1).

All items relating to production factors were deducted from the Regional Price List of the Sicily Region and, alternatively, from that of the Emilia–Romagna Region 2021 [118].

On the basis of the geometric characteristics of the building unit, type of roof (roof, terrace, mixed etc.), the size of the technological components and the individual works envisaged for each RWT, the total costs of the works were calculated for each BU according to the Assigned RWT (extensive, intensive, mixed).

Table 1. Price analysis.

Work Group	Id. Cod.	RWT	UM	Materials	Labor	Capital	Total Unit Price
Removal		A1	Sq. m	4.70 €	17.70 €	1.44 €	23.84 €
		Ba1	Sq. m	0.98 €	3.67 €	1.44 €	6.09 €
		Bb1; Bb2	Sq. m	1.96 €	7.35 €	3.83 €	13.14 €
		all	Sq. m	0.69 €	2.58 €	3.27 €	6.54 €
Restoration	GR100GN	all	rmt	23.00 €	10.75 €	-€	33.75 €
Materials	DIFU STOP ALU 1500	Ba1; Bb2	Sq. m	2.28 €	1.19 €	0.00 €	3.47 €
	DELTA ®-NOVAFLEXX	A1	Sq. m	3.37 €	1.01 €	0.00 €	4.38 €
	Durock Energy Plus [119]	A1; Ba1	Sq. m	12.90 €	3.52 €	1.13 €	17.55 €
	BauderPIR FA TE	Bb1; Bb2	Sq. m	14.70 €	6.88 €	1.08 €	22.66 €
	BauderSMARAGD	all	Sq. m	19.90 €	10.66 €	0.00 €	30.56 €
	Bauder FSM 600	all	Sq. m	3.90 €	1.34 €	-€	5.24 €
	Bauder PE 02	Bb2	Sq. m	0.70 €	0.66 €	-€	1.36 €
	Bauder SDF	A1; Ba1	Sq. m	8.90 €	0.81 €	-€	9.71 €
	Bauder DSE 40	Bb1	Sq. m	12.10 €	0.80 €	-€	12.90 €
	Bauder WSP 75	Bb2	Sq. m	20.00 €	1.25 €	-€	21.25 €
	Bauder FV 125	all	Sq. m	1.20 €	0.66 €	0.00 €	1.86 €
	Bauder LBB-E	A1	Sq. m	1.13 €	2.44 €	0.01 €	3.58 €
	Bauder LBB-E	Ba1	Sq. m	1.13 €	2.44 €	0.01 €	3.58 €
	Bauder Intensive	Bb1	Sq. m	2.82 €	6.10 €	0.01 €	8.93 €
	Bauder Intensive	Bb2	Sq. m	4.23 €	9.14 €	0.01 €	13.39 €
	DAKU GRID 3	A1	Sq. m	4.60 €	1.19 €	0.00 €	5.79 €
	DAKU GEO 75	A1	Sq. m	7.80 €	1.19 €	0.07 €	9.05 €
Accessories	Wooden stand	A1	rmt	4.29 €	4.29 €	-€	8.58 €
	Daku Pro 80—AL	A1	rmt	14.20 €	0.94 €	-€	15.14 €
	Fixing bracket	A1	rmt	7.50 €	1.50 €	-€	9.00 €
	Daku controller	all	apiece	55.50 €	2.62 €	-€	58.12 €
	Bauder 150/60 MR	all	rmt	90.00 €	2.00 €	-€	92.00 €
	Connecting element	all	rmt	9.10 €	-€	-€	9.10 €
	Closing element	all	apiece	26.00 €	-€	-€	26.00 €
Greening	Sedum	A1; Ba1	Sq. m	7.00 €	6.00 €	12.46 €	25.46 €
	Small plants	Bb1	Sq. m	8.40 €	7.20 €	12.46 €	28.06 €
Ph. panel	LG Solar Neon2	C1	apiece	240.00 €	75.79 €	-€	315.79 €
BIPV	Tegosolar	C2	Sq. m	87.19 €	37.04 €	0.00 €	124.24 €

3.3.3. Calculation of Available Areas for Photovoltaic Systems

The Borgata di Santa Lucia is the most recently formed part of the historic center of Syracuse and, as such, is subject to a landscape restriction that regulates the use of roofs for photovoltaic exploitation, prohibiting the installation of panels on sloping pitches and allowing them on flat roofs but limited to those portions that are not visible from public areas.

Consequently, the portion of the flat roof that can be used for this purpose depends on the setback of the panels from the eaves line by a sufficient distance so that they are not visible from the street (or square); this distance was calculated for each BU with a complex function whose arguments are the height of the floor and the width of the street (Figure 10).

Finally, the area necessary for the installation, maintenance and inspection works was subtracted from the surface calculated, as above mentioned.

(a) (b)

Figure 10. (**a**) Map of the visibility of photovoltaic systems measured by the distance at which they are visible from public areas; (**b**) study to calculate the setback of photovoltaic systems from the eaves line.

4. Applications and Results

The results of the application consist in the generation of 100 Strategies (20 for each of the five above-mentioned Approaches) and in their synoptic evaluation from the point of view of the four matrices: Landscape, Identity, Energy–Environmental and Economic. Accordingly, the ultimate and most synthetic valuation of each Strategy is represented by a four scores vector.

The synoptic evaluation consisted in comparing the Strategies through quadruples of Cartesian planes connected to each other by the fact that the y-axis of each one became the x-axis of the next one. In this scheme, each strategy was represented by four points (one for each plane); each set of 20 strategies defined, for each of the four couple of variables (x-axis and y-axis), a relationship that could be of tendential convergence (direct) or trade-off (inverse).

The results of the two Modalities are described and represented below.

Modality 1 consists of Approach 0 alone, where the quadruples of the Cartesian planes of four example strategies out of the 20 developed are highlighted by the larger graphs; the preferred layout is indicated for each graph by the corresponding square connecting the four points.

Modality 2 consists of four approaches where the quadruples of the Cartesian planes of three example strategies out of the 20 developed are reported and mapped; the preferred layout is indicated as above.

For each approach, some comments provide the guidelines for the interpretation of the effects of the progressive constraint release.

4.1. Modality 1, Approach 0

The early experimentation of the model application (Modality 1) concerns the approach assuming, as Strategy 1, the maximum green surface of the neighborhood roofing (Green) and, as Strategy 20, the maximum real estate exploitation allowed by the guidelines of the Detailed Plan (Grey). The graphs in Figure 10 exemplify the results of the progressive release of the constraints, providing a cluster of 20 strategies that show the trade-off between Energy–environmental and Identity matrices, as well as between Landscape and Economic matrices; similarly, the convergence relationships between Energy–environmental and Economic matrices as well as between Identity and Landscape matrices are outlined. The trends of the scatters show how the urban context reacts to the progressive release of the constraints, progressively blurring from Green to Grey.

The analysis of the results shows that strategy 13 had the lowest aggregate overall score, while strategies 3 and 18 were in the highest range of the ranking by the overall performance index. In general, a low degree of preferability was observed.

Ranking the strategies by score, from the lower to the higher, two broad clusters of strategies were identified that were very similar to each other. The first consisted of strategies 16, 15, 7, 8, 9, 10 and 6, whose scores were very close to the average score of 3.47, and the second consisted of strategies 2, 17, 1, 20 and 19.5, with scores very close to the average of 3.99.

On the basis of these premises, the hypothesis of a strategy of widespread green roof intervention was, from the outset, the main inspiration for this research.

Subsequently, in order to exclude any possible bias, alternative hypotheses were also investigated to interpret the context in light of the four outlined perspectives (Figure 11).

4.2. Modality 2

The further experimentation concerned the second modality of generating Strategies, according to four Approaches: Green (2), Blue (3), Green–Blue (4) and Grey (5), with each approach resolving the ambiguity of sorting BUs according to each prospect.

Notice that Approach 4, Green–Blue, was defined in view of the opportunities related to the integration of green roofs with photovoltaic systems. The Green–Blue Approach expresses landscape and identity values (green) as well as economic and energy and environmental values (blue), simultaneously.

Modality 2, overall, which is regardless of the four approaches, enables:

- Green roofs until Strategy 10,
- Blue roofs until Strategy 17 and
- Grey roofs until Strategy 20

As can be noticed comparing Figure 10 to the next ones, the second modality overcomes the programming pattern based on trade-off. The results of the implementation of these approaches show that:

- it is no longer possible to outline homogeneous clusters of strategies, with almost similar evaluations;
- despite the gradual release of constraints, sudden valuation gaps occur between successive strategies;
- it is no longer possible to identify almost continuous paths of convergence;
- fully dominant strategies are identified, albeit characterized by very different performance profiles.

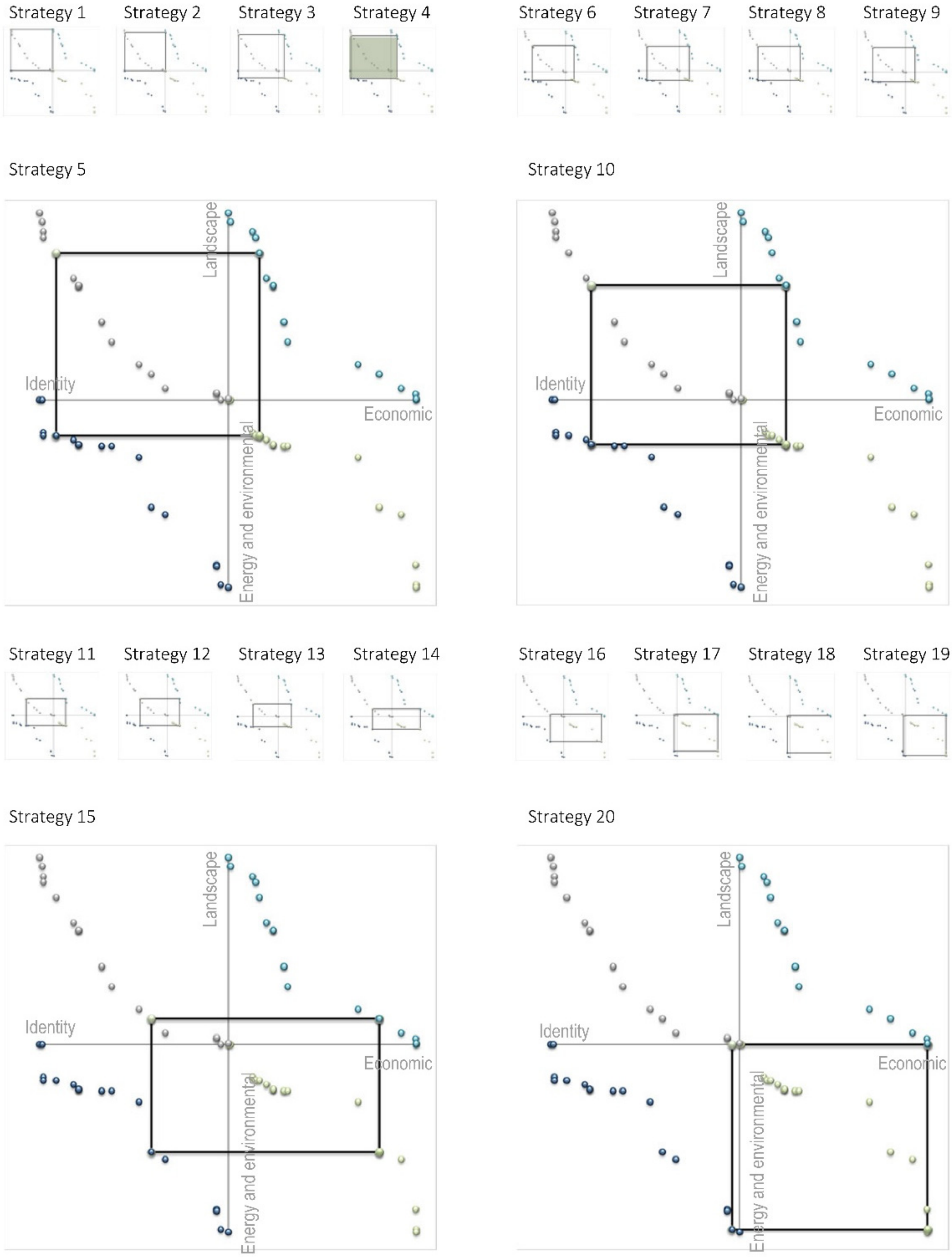

Figure 11. Integrated valuation of the 20 Strategies of Approach 0; Strategy 18 was the preferable one.

4.2.1. Approach 1

The first approach did not show homogeneous clusters, except for the two groups of strategies 10, 11, 12 and 13 and 17, 18, 19 and 20, which, when compared based on the scores, were significantly different except for strategies 11 and 12, which had the same score.

The release of constraints abruptly enabled a significant number of interventions only starting from Strategy 6; they gradually increased until Strategy 20, which, however, was unable to involve the whole sample (Figure 12). In fact, although constraints were released gradually, since some characteristics (such as, for example, the type of roofing of pitched, terraced, mixed and terrace and canopy and building type) did not vary gradually, there were abrupt changes in the overall scores of the Strategies.

Finally, the dominance of strategies 19 and 20, with equal scores of 5.13, could be recognized.

4.2.2. Approach 2

In the second approach, a first cluster formed by strategies 1–5 and a second one grouping strategies 10–20 could be identified.

Gradually less homogeneous gaps could be observed, in particular, between strategies 6 and 7, 7 and 8 and 9 and 10.

The preferable strategies of 19 and 20, which were indifferent to each other, could not be considered actually preferable, given the small gap between them (Figure 13).

4.2.3. Approach 3

The third approach was characterized by an abrupt change in the aggregate score from Strategy 4 to 7. The value card of the aggregate score from 14 to 20 indicated a weak responsiveness of the aggregate score to the subsequent succession of strategies. The (slightly) preferable Strategies, in this case, were 19 and 20, with a score of 8.38.

Furthermore, strategy 20 of Grey–Blue appeared to be the analyzed approach with the highest score (Figure 14).

4.2.4. Approach 4

The fourth approach confirmed the abrupt variation in strategies 4–7 and the presence of an extended cluster consisting of strategies from 12 to 20, while the remaining strategies evolved with abrupt positional deviations due to the constraint release setting that gradually enabled Grey Roofs, starting from strategy number 16 (Figure 15).

A weak preference was given to Strategies 17 and 18, both with a score of 7.95 (Figure 15).

A synthesis of the results of the above applications is reported in Table 2, showing the quantitative contents (number of roofs enabled) and qualitative profiles (global assessment from the perspective of the four axiological matrices) of the preferable strategies of each approach.

Figure 12. Modality 2, Approach 1 (Green) Strategies 10, 16 and 20. The latter turned out to be the preferable one of Approach 1.

Figure 13. Strategies 10, 16 and 20 of Modality 2, Blue approach.

Figure 14. Strategies 10, 16 and 20 of Modality 2, of the Green–Blue approach.

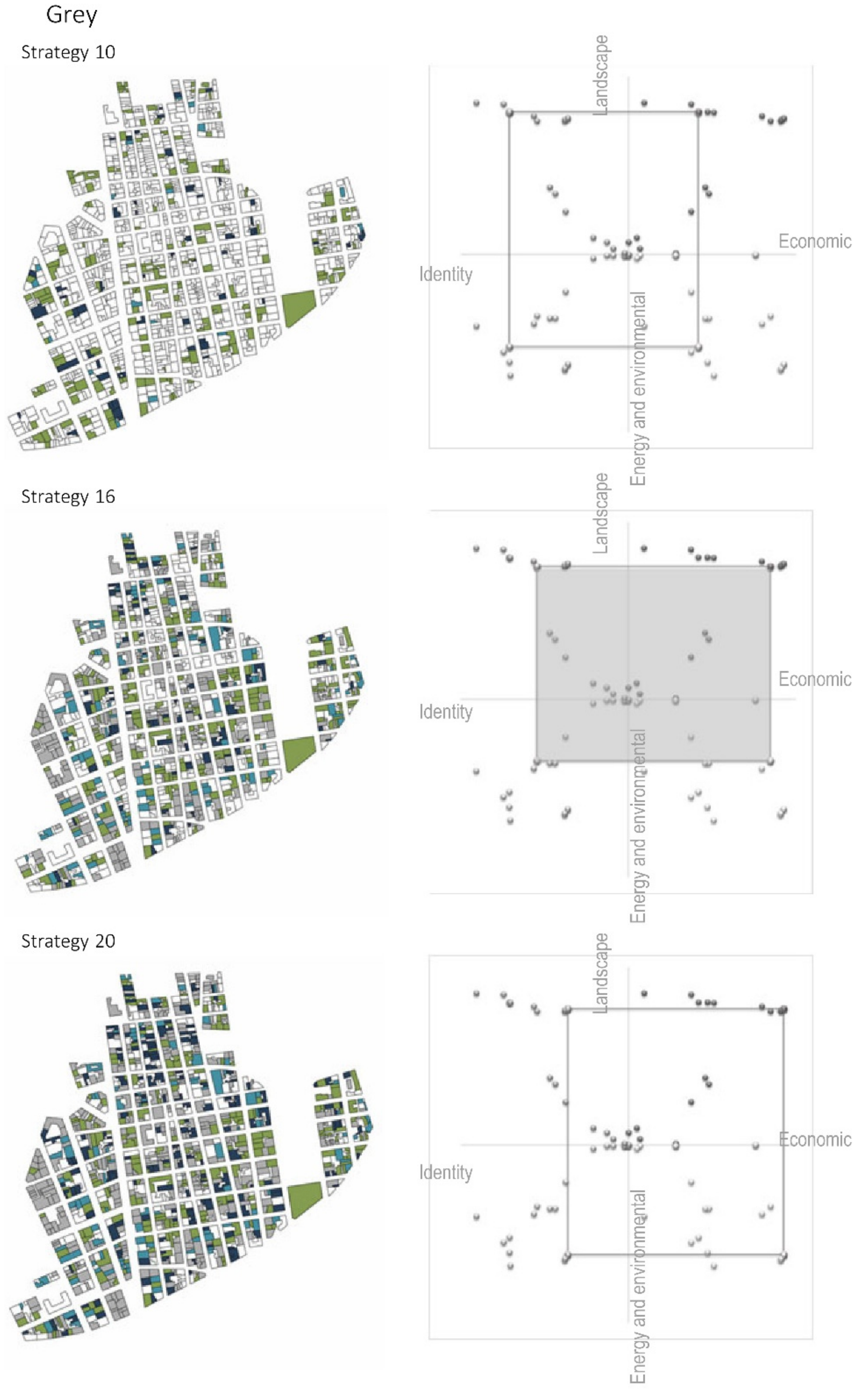

Figure 15. Strategies 10, 16 and 20 of Modality 2, of the Grey Approach.

Table 2. Synthesis of the quantitative results of the most preferable strategies included in the five approaches.

			Number and Types of Roofs Involved				Qualitative Assessment Score by Axiological Matrix			
Modality	**Approach**	**Preferable Strategy**	**Green**	**Blue**	**Green–Blue**	**Gray**	**Landscape**	**Identity**	**Energy-Environmental**	**Economic**
1	0	4	713	33	0	0	1.74	1.96	0.38	0.29
2	1	20	541	277	7	46	0.96	1.62	1.17	0.80
2	2	20	193	620	12	46	0.96	0.63	2.00	2.00
2	3	20	427	277	121	46	2.00	1.30	1.54	1.07
2	4	16	222	81	103	316	1.58	1.15	0.73	1.77

5. Discussion

Some of the limitations of this research are implicitly due to the very process of reducing the complexity of the urban context to elementary information units. As a consequence, the next transformation of them in value judgements supporting the choices of the roof type could appear as an abstraction.

For these reasons, further conditions have been considered in order to formalize, in five oriented approaches, the different modalities of solving the ambiguities coming from the above approximation.

Consistent with this perspective, the combinatorial mechanism of the three main Roof Work Types prefigures new possibilities, as experimented by introducing the RWT of Green–blue. As a result, this “compromise” creates the preferable strategies from the perspective of the four axiological matrices.

Further combinations of the basic RTWs, as for the BUs where a floor can be added, can be Green–Grey, Blue–Grey and Green-Blue–Grey. Accordingly, the model allows Modality 2 Approaches to be applied to Modality 1 as well; so that generating 20 strategies for each of the seven Approaches of the two Modalities, 280 Strategies can potentially result.

Moreover, should it be decided to release the constraints in a different manner, further meta-scenarios could be generated, and this would complicate the problem exponentially.

Indeed, the significance of such a “heuristic” lies in the practice of *skepsis*, i.e., “the research that questions acknowledged truths and recognizes the potential of doubt” [106]. In this sense, the value of the proposed model does not consist in its ability to generate a lot of scenarios, but rather, to create the space for the right choice to manifest itself, thus contributing to the knowledge of value and its creation.

This research practices a green city approach and provides, within it, a planning tool for building interventions on the neighborhood-scale.

The approach practiced reflects the disciplinary orientations aimed at organizing collective intelligence in view of the sustainable and inclusive ecological transition.

The tool reduces the subjectivity of value judgements and choices, through two phases: the first, “inflative”, i.e., aimed at producing knowledge, consists of the prefiguration of a large number of mutually coherent strategies; the second, “deflative”, i.e., aimed at reducing this amount of knowledge to only “sensate”, consists of the evaluation and choice of the best strategy.

This is why the generation of alternatives requires experience and evaluative awareness, as well as knowledge of the significance of the constraint and of the relevant variation range; this knowledge and sensitivity allow this excess of information to be deflated, assuming a particular heuristic importance [120].

In the absence of a sustainability goal-driven approach and a tool for evaluation and choice, either centralized choices, indifference on the part of citizens or pressure from the most influential stakeholders may prevail.

Similar to previous experiences [121], such an approach preludes to the active and informed participation processes concerning the building permissions, incentives and fee management on a neighborhood-scale; in fact, basing on the easily accessible information, stakeholders can take part in any negotiations and be aware about the map of advantages and disadvantages of each strategy.

6. Conclusions

This research has dealt with an aspect of the regeneration of the historic city: the use of roofs. This issue is relevant from the two converging perspectives of the city landscape and identity unity.

Although mutually supportive, these two issues involve technological, axiological and decisional matters [122], which the proposed model integrated basing on the evaluation and decision-making aimed at outlining the different layouts of the multiple aptitudes to the green transformation of the neighborhood.

Accordingly, this experiment answered the research question concerning the role of the green re-use of roofs for the reform of the "house–city–landscape system", and how the considerable public investments in the ecological transition can improve the collective consciousness and determination necessary to integrate energy–environmental [123–130] and landscape issues in the creation of a new solidary neighborhood identity [131–135].

Such an approach is consistent with the general prospect of triggering co-benefit [136] in the broader social and landscape perspective, since it holds together:

the unity of the intervention program aimed at creating a neighborhood identity inspired by the most up-to-date practices of sustainability;

- a flexible planning approach allowing decision makers to explore the potential creation of overall value by generating and real-time evaluating multiple layouts of the arrangement of the RWT to be associated to the BUs;
- the reduction of the decision-maker's arbitrariness, since every single layout is generated as a whole strategy operating on the rules, not on the BUs;
- the statement of the rules by which the function of multiple (convergent and/or conflicting) preferences is optimized through the creation of the preferable strategy.

The application provided a broad and orderly overview of strategies, each reflecting the upstream preference system (and of two types).

The first (Modality 1) mostly highlighted the conflict between landscape-identity and energy–economic perspectives, according to a typical trade-off approach; in this case, the best strategy involved the maximum extension of green roofs.

The second (Modality 2) showed that the value increased, starting from the 0-Option, and created the above converging–conflicting trends, only starting from the middle strategy (the 10th, roughly); in this case, the best strategies (one for each of the four approaches, differently mixed the RWTs according to the corresponding preference system.

Further in-depth analyses concern overcoming of the additive approach practiced here, which, on the one hand, supports a robust detailed analysis carried out by elementary information units, and on the other hand, reduces the typical holistic vision characterizing the organic urban units.

Based on the results obtained, and by projecting the latter on a neighborhood-scale, the potential green identity of a city can be synthetically outlined, thus creating more comprehensive maps of urban sustainability. The interactive, participative and equalizing potential of the approach proposed meets the need for making urban and design policies definitely inclusive.

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