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Article

Environmental Design Principles for Urban Comfort: The Pilot Case Study of Naro Municipality

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Abstract: Nowadays, considering the urgent issues related to climate change and land consumption as well as the increasing urban population, urban spaces, enhanced by appropriate design solutions, can help reduce risks and improve conditions of environmental well-being. In this context, thanks to a collaboration between the Department of Architecture of the University of Palermo and the Municipality of Naro, in the province of Agrigento (Sicily, Italy), an urban environmental design workshop was promoted to redefine an urban space without a precise identity and denied to public use, within the fabric of a minor historical center in the Sicilian hinterland. The article summarizes the adopted methodology, including the population needs' assessment, the environmental context assessment, the historical analysis of the urban space to redefine within the context of the whole historical center, possible urban and greening solutions, and design references according to the urban biophilic approach. The resulting preliminary design aims to be an example of an interdisciplinary approach, respectful of what already exists, which places the comfort and well-being of the user at the center of the design. Moreover, it is an interesting example of urban regeneration through the biophilic approach applied to a small urban center, which could be replicated in other similar contexts.

Keywords: urban regeneration; biophilic design; sustainable architecture; urban greening; environmental design; urban comfort; urban biophilic approach

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1. Introduction

Climate change, the growth of urban populations, and land consumption, are driving transformations in cities worldwide. By 2050, urban populations will increase by 2.5 billion, reaching 68% of the global total [1]. Urban spaces, ranging from parks to small public squares, play a critical role in fostering socialization and improving environmental health. Today, in light of the potential risks arising from climate change, which increasingly threaten human settlements, the capacity for adaptation, resilience and mitigation offered by urban spaces, both public and private, enhanced by the application of appropriate design solutions, can help reduce risks and improve conditions of environmental well-being.

Urban space is commonly understood as a public place in which activities of simple crossing, meeting, leisure, and socialization take place. At the macro-urban scale, it is identified with pedestrian and/or multimodal streets, squares, and parks, while, at the micro-urban scale, with gardens, vegetable gardens, paths, small squares, and open spaces.

In response to climate risks, thoughtful design of both public and private urban areas—through green spaces, cooling technologies, and climate-resilient features—can enhance adaptability and mitigate urban heat, improving air quality and well-being [2]. Numerous examples of how urban design can address climate change risks have been realized in the last years, demonstrating how urban planning can not only adapt to climate change but also promote sustainability and resilience, improving the quality of life for urban populations. Just to mention an example, Copenhagen has become a pioneer in urban cycling infrastructure, integrating cycling into the city's transportation system in order to improve public health and reduce pollution. The city has over 390 km of bike lanes and a "Green Cycle Route" connecting cyclists to all the parks and the urban and extra-urban green spaces. Moreover, initiatives like the "Copenhagen Bike Share" and large investment in cycling-friendly infrastructure, have led to a 40% reduction in car use in the city center [3–5]. In Singapore, to face the rapid urbanization and flood risks, the integration of green spaces such as parks, rooftop gardens, and vertical greenery have been implemented, allowing the reduction of the urban heat island effect, improving air quality, increasing the biodiversity and, as a result, promoting urban climate resilience [6–8]. Interventions, such as the Tropical House project in Singapore by architect Garry van der Griend, which includes communal gardens, rooftop green spaces, and natural ventilation, allowing residents to engage with nature, not only contribute to environmental sustainability but also provide opportunities for social interaction, recreation, and community building [9]. By creating accessible green spaces within urban environments, the project encourages a collective connection to nature, thereby improving mental health and well-being for all residents, regardless of income or background [10].

This contribution is the main output of a workshop promoted by the Department of Architecture of the University of Palermo in collaboration with the Municipality of Naro, in the province of Agrigento (Sicily, Italy), and focuses on the case of an urban space without a precise identity and denied to public use, within the fabric of a minor historical center in the Sicilian hinterland. Through some reflections on the analysis of citizens' needs, as well as on the characteristics of the environmental context, the space is redesigned with a biophilic approach, which aims to create an oasis of comfort; the well-being of the users of these spaces becomes the main objective of the project. Following Singapore's example, the integration of greenery, the creation of shaded rest areas, spaces for conversation or play, the addition of a panoramic walkway, the choice of using natural materials, and attention to physical accessibility for the disabled, are the elements for the design of a place with a strong identity that communicates with the urban fabric, grafting onto the historic staircase and improving its livability.

This means no longer considering the indoor space separate from the outdoor space, but rather aiming for the integration between them using the urban "greening project" as a filter, bringing widespread well-being. The appropriate use of green and blue technologies is in fact studied and evaluated as a substantial method for the health of the city of Naro, through the adoption of suitable tools for the mitigation of urban heat, the improvement of air quality, and the enhancement of biodiversity. In this case, the relationship of strong interconnection and interdependence between architecture and nature requires a paradigm shift that places the relationship between human beings and the environment in a new perspective, assuming an eco-centric and no longer ego-centric vision [11].

In this perspective, the project in Naro is intended to be an example of an interdisciplinary approach, respectful of what already exists, that places the user's comfort and well-being at the center of the design. This example is easily replicable and adaptable in other contexts that can greatly benefit from targeted interventions and is capable of preserving the environment, improving the quality of life of residents, and building more cohesive and resilient communities. This biophilic design approach, as in the Tropical House in Singapore, emphasizes the integration of nature into urban life while promoting social equity and cohesion, proving that sustainable, nature-infused architecture can also enhance social inclusion.

In methodological terms, the research project was based on five fundamental focuses:

Sustainability and environmental comfort: integrating sustainable practices such as the use of renewable energy, the creation of green areas and the promotion of sustainable mobility.

Improvement of the quality of life: enhancing infrastructure and public spaces, making the municipality more livable and attractive to its inhabitants.

Innovation and creativity: creating environments dedicated to innovation and creativity, hosting cultural, artistic and social events that stimulate intercultural dialogue.

Social cohesion: encourage the active participation of citizens in the management of spaces, strengthening social ties and a sense of belonging.

Economic revitalization: stimulating the local economy by attracting tourists and investments, creating jobs, and supporting commercial activities.

The project response represents a concrete opportunity to improve the economic, social, and environmental well-being of the Municipality of Naro, helping to build a more prosperous and sustainable future. Involving the community means ensuring that projects authentically respond to local needs and aspirations, leading to lasting and significant results.

1.1. Urban Space Functions and Requirements

All urban public spaces are characterized by specific functions. The first study on the possible uses of public space in the city is due to the Danish architect Jan Gehl, author of a work that is still of valid help today for the definition of the relationships between public spaces and use. The author identifies the functions of public space in relation to the activities that can be carried out, distinguishing them as necessary, voluntary, and social [12]. Necessary activities are independent of our will but fall within a scope linked to the daily commitments of each individual, such as moving to go to work or study, shopping, or running errands. Instead, voluntary and social activities are actions that each of us chooses to do for our own pleasure or enjoyment such as taking a walk, playing sports, meeting people, playing, reading a book, participating in meetings, concerts, and temporary exhibitions. The function of these spaces is to attract different types of people. If a public space has poor environmental quality, it is destined to host only necessary activities that must be carried out continuously regardless of the weather conditions or the pleasantness of the route. It is also true that if the public space in which necessary activities take place is welcoming, this certainly improves the comfort of passers-by. Voluntary and social activities, on the other hand, all being actions that people choose to do, require welcoming spaces that can be used even for extended periods of time.

In order for all urban public spaces, whether intended for necessary activities or voluntary and social activities, to guarantee conditions of usability and well-being, they must possess compositional and aesthetic qualities as well as requirements of livability, attractiveness and comfort.

1.2. Comfort Outdoors: Environmental Variables and Intervention Strategies

Comfort is the result of a sum of concomitant sensory perceptions due to environmental and subjective variables. Environmental variables are identified with air quality, microclimate, sound, and light; subjective variables depend on the characteristics of the clothing worn or the overall thermal resistance that these oppose to heat transfer, but they also depend on energy expenditure, or the energy produced by metabolism by the body surface during each activity performed.

Different sensory perceptions can determine sensations of thermo-hygrometric, respiratory–olfactory, acoustic, and optical–visual well-being (or discomfort) that define indoor and outdoor environmental comfort.

To ensure the environmental comfort of an urban space, it is necessary to proceed with the environmental analysis of the area under study, followed, if necessary, by proposals for appropriate strategies aimed at improving the conditions of well-being and which can be solutions with a prevalently natural character (*nature-based* solutions—*green solutions*), with a prevalently artificial character (*grey solutions*) or mixed (*blue solutions*) (Figure 1).

Figure 1. Examples of *green solutions* (**left**), *grey solutions* (**middle**), and *blue solutions* (**right**).

Environmental analysis involves determining the geographical location as well as carrying out accurate investigations into air quality, thermo-hygrometric conditions (solar radiation, temperature, air speed, relative humidity), lighting conditions, and noise levels.

1.2.1. Air Quality

The factors that significantly influence air quality are the presence/absence of pollutants and smog from vehicular or industrial traffic. These are data that can be deduced using specific instruments.

The Swiss company IQAir periodically publishes the report on the healthiness of the air around the globe, [13] indicating the AQI index (Air Quality Index) which focuses on the measurement of particulate matter PM10, PM 2.5, carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide. According to the latest findings, the cities with a higher AQI value are Lahore, in Pakistan (AQI 268), Delhi in India (AQI 212), and Ulaanbaatar in Mongolia (AQI 206). The cities with the lowest AQI are the US cities of Minneapolis (AQI 7) and Denver (AQI 13). Italy is currently in the moderate range with Milan (AQI 80) and Rome (AQI 60) (Figure 2). Without prejudice to the fact that the data are highly fluctuating and vary from day to day and from hour to hour, the overall picture of the global situation in terms of air quality is quite clear.

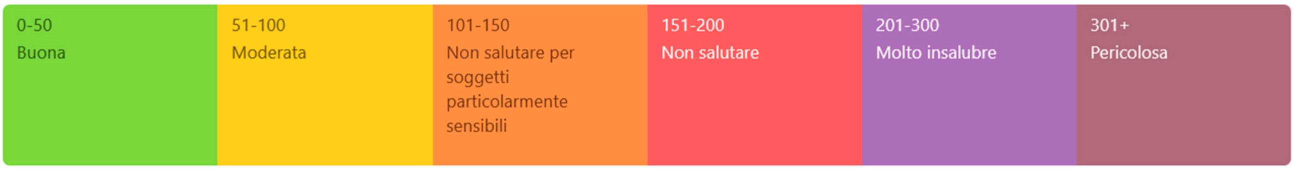

Figure 2. US AQI+ legend from IQAir report.

According to data collected in 2022 by Arpa Sicilia in the Agrigento area where the city of Naro is located, the annual average of NO_2 emissions was 10 $\mu g/m^3$, PM10 $\mu g/m^3$ 18, values that fall within the Good/Moderate bands [14]

The environmental pollution caused by the entire waste production process, from the extraction of raw materials to their disposal, also deserves appropriate attention, with the consequent generation of waste products and emissions into the atmosphere being able to be mitigated through reuse policies and alternative uses for which no further consumption of energy resources or activities involving further production of pollutants are required.

Natural strategies aimed at improving air quality essentially materialize with the use of vegetation which, at the macro and micro scale, also contributes to improving the attractiveness of an urban space. Strategies with a prevalently artificial nature can be traced back to the use of coatings and paints with particular properties that allow the degradation of harmful organic and inorganic substances present in the air. Photocatalytic titanium dioxide paints are particularly interesting. Exposure to sunlight allows the activation of the photocatalytic chemical reaction, ensuring a daily decrease in harmful gases present in the surrounding environment. Mixed strategies include solutions that involve the presence of moving water, obtained from fountains and jets. The air near moving water is particularly rich in negative ions that neutralize polluting molecules and microbes.

1.2.2. Thermohygrometric Conditions

The factors that influence thermo-hygrometric conditions, i.e., the thermal exchanges between the subject and the external environment, depend substantially on the morphological and dimensional characteristics of the urban space, which act predominantly on the quality of life of users as they determine the conditions of solar radiation and the consequent air temperature, but also the action of the wind, humidity, glare phenomena, and sound dissipation (Figure 3). Thermohygrometric conditions are also influenced by the characteristics of the soil and covering materials.

Figure 3. Incidence of solar radiation in different urban spaces.

Solar radiation. The dimensions of external spaces are decisive for the incidence of solar radiation on the soil. Knowledge of the sky view factor (SVF), i.e., the quantity of portion of sky visible from a point in the urban space, allows us to determine the quantity of solar radiation that can affect the urban space during the day. If the sky is completely visible, the SVF value is equal to 1; if it is not visible at all, the SVF value is equal to 0.

In very large or medium-large open spaces, surrounded by low-rise buildings, solar radiation directly impacts the ground, which partly reflects it and partly absorbs it, subsequently emitting it in the form of heat (Figure 4a,b). This condition significantly influences the air temperature, contributing to increasing the heat island phenomenon, which is one of the main factors to pay attention to in outdoor areas of rest and passage. In smaller spaces, the presence of neighboring buildings affects solar radiation with effects and consequences on the penetration of sunlight and perceived temperature. In large or medium-large spaces surrounded by low-rise buildings, natural strategies aimed at controlling solar radiation can also be traced back to the use of vegetation, while artificial ones can include the creation of porticos, canopies, paths, and covered areas (Figure 4c,d). In smaller spaces with adjacent buildings, solar radiation control can be achieved by creating awnings, pergolas, and shelters (Figure 4e,f).

Shading canopies equipped with photovoltaic cells can act as protection from daytime solar radiation and as an energy storage system for night-time lighting.

Huge solar umbrellas, inspired by sunflowers and designed by the Australian studio LAVA Architects for Masdar City, open like flowers during the day and close in the evening, transforming into luminous buds that release stored heat, mitigating daily temperature variations (Figure 5).

The presence of fountains and bodies of water can help mitigate the rise in temperature caused by solar radiation (Figure 6a,b).

The thermal and mechanical effects generated by the wind can positively or negatively influence the outdoor comfort conditions of large or small outdoor spaces. The presence of adjacent buildings can also contribute to the formation of air currents and fluctuations in perceived temperature. The benefits of air currents are highly desirable in the hot season and in the presence of high levels of relative humidity that can also be found in densely green areas, also influencing the perception of heat or cold. In this case, it is necessary to promote ventilation with structures that channel the wind or elements that create discontinuity.

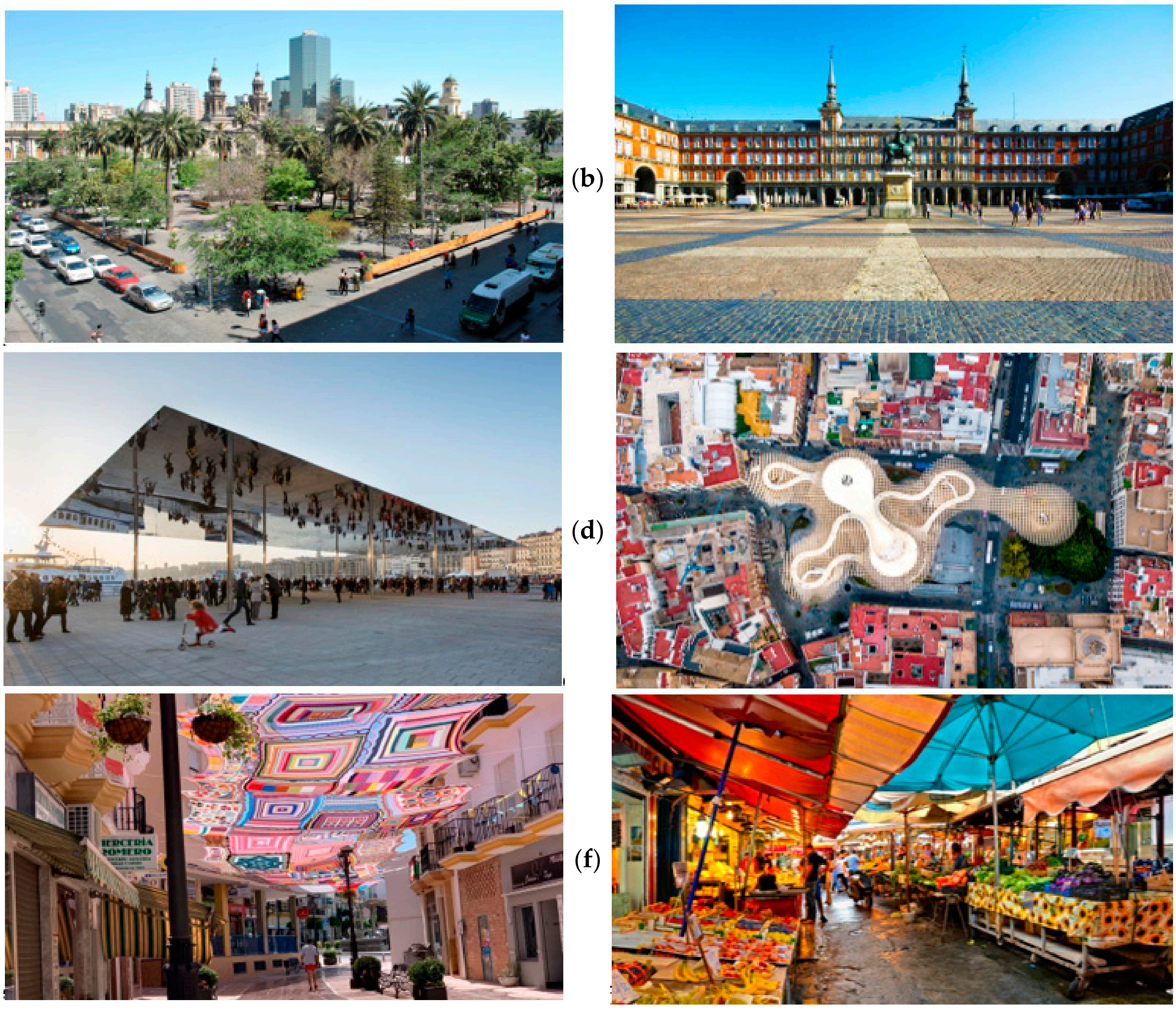

Figure 4. (**a**) Plaza de Armas, Santiago, Chile; (**b**) Plaza de Armas, Madrid, Spain; (**c**) canopy in the old port of Marsiglia, France, by architect N. Foster, 2013; (**d**) Metropol Parasol Siviglia, Spain, by architect J. Mayer H., 2011; (**e**) maxi-tent made with crochet to protect the streets from the summer heat, Alhaurín de la Torre, Malaga, Spain; (**f**) covered market of Ballarò, Palermo, Italy.

Figure 5. Solar umbrellas designed for Masdar City, LAVA Architects.

Air flows. Mechanical effects can instead generate uncomfortable conditions and therefore it is necessary to adopt speed control and damping systems. A valid green strategy for controlling air flows and mitigating the effects of the wind in large spaces is the provision of hedges and green barriers (Figure 7a,b), made with evergreen trees placed at different heights and with large foliage that acts as a windbreak. Windbreaks can also be created through grey solutions that involve the use of prefabricated elements of the most diverse shapes, sizes, and materials. More technological solutions are dissipators. Green or prefabricated windbreaks are also recommended for small spaces.

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

Figure 6. (**a**) Miroir d'Eau, specchio d'acqua di fronte a Place de la Bourse, Bordeaux, Michel Corajoud; (**b**) Martin Luther King Park, Atelier J. Osty, Paris, 2014.

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

Figure 7. (**a**) Green barriers at different heights; (**b**) deflectors made of steel frames covered with perforated aluminum to reduce wind speed, Bridgewater Place, Leeds, England, 2005.

Whether it is a large open space, or a small space, the nature of the soil and the covering materials can influence the thermo-hygrometric conditions of an urban area, also acting on the heat island effect in the lower layers. Evapotranspiration is facilitated by porous and humid surfaces such as, for example, lawns; on the contrary, it is prevented by impermeable surfaces that tend to accumulate considerable quantities of heat.

It is possible to obtain an evaporative cooling effect also by taking examples from technological solutions tested in the past, used to improve the thermo-hygrometric conditions in particular environmental situations by exploiting renewable energy sources. Technological solutions such as, for example, the Iranian wind towers that capture and channel the wind inside homes, are today revisited in a contemporary key for the evaporative cooling of open spaces and squares in particularly dry climates.

The wind tower built in a square in Masdar City, in the United Arab Emirates (Figure 8), is an example of the integration of ancient knowledge and advanced technologies that allow us to obtain models of sustainable environmental compatibility to offer naturally cooler outdoor public spaces. The automated louvers, placed high up and controlled by sensors, capture the wind, while jets of water humidify the cooled air which is conveyed downwards and distributed in the square and among the city streets.

It is also possible to obtain an evaporative cooling effect on floors made with artificial permeable materials that allow the surface flow of rainwater under a substrate placed just below the walking surface and made with materials that favor the retention of water. The heat present on the surface of the floor is transferred by conduction towards the water, which in turn evaporates, dissipating into the ground below [15].

Figure 8. Wind tower in Masdar City, United Arab Emirates, Foster and Partners, Abu Dhabi.

Solar reflection depends not only on the nature of the material but also on its color; the darker a surface is, the less it will reflect, while the lighter the material, the greater its reflection coefficient (albedo). The choice of appropriate materials, especially for flooring, significantly contributes to improving thermal comfort, avoiding the heat island effect. Dark and rough materials, called "warm materials", dissipate less heat which, by accumulating, determines an increase in the temperature of the surfaces of the coverings (Figure 9b). This can be a solution for cold climates, where it is necessary to make the most of the effects of solar radiation which, as is known, is significantly lower than that enjoyed in countries with hot climates. In the latter, in fact, materials with a high thermal reflection power must be preferred, therefore light and smooth materials, also called "cold materials". It is also possible to increase the amount of reflected solar energy by using so-called cold pavements (*Cool Pavements*), obtained by inserting specific pigments, paints, or aggregates in the composition of outdoor flooring that help keep the surfaces colder than traditional pavements. The effects of cold materials and pavements must, however, be controlled, as the portion of reflected radiation could be excessive and negatively affect comfort (Figure 9a).

Figure 9. (**a**) Cool pavement; (**b**) hot pavement; (**c**) combined pavement.

The regulation of the external temperature can also be obtained by appropriately exploiting the combination of cold materials and hot materials, as the difference in surface temperature and the consequent difference in pressure between the hot air and the cold air produces convective motions that reduce the perceived temperature (Figure 9c).

1.2.3. Lighting Conditions

If the use of very light covering materials can be useful to improve thermo-hygrometric conditions in hot climates, it is also true that high solar reflectance can worsen not only the thermal comfort conditions but also the visual comfort, with glare phenomena similar to those caused by glass and mirror materials (Figure 10a–c).

Figure 10. (**a**) Pedestrian path in Ostuni, Italy; (**b**) glass building envelopes; (**c**) storage area of the Boijmans van Beuningen Museum in Rotterdam, Netherlands, by MVRDV architectural firm; (**d**) velarium of the Colosseum, Rome, Italy; (**e**) portico of the cloister of San Zeno Maggiore in Verona, Italy; (**f**) fixed screens in the Park of the Nations, Lisbon, Portugal.

The brightness conditions in outdoor environments are generally connected to the intensity of solar radiation and therefore, the strategies adopted to improve visual comfort are very similar to those envisaged for thermal comfort. The most common system, and the most used throughout history, is the provision of fixed or mobile fabric screens and canopies of various kinds, but also the creation of colonnaded porticos. Today, advanced materials are used, more or less effective, but the solutions are mostly the same (Figure 10d–f).

1.2.4. Noise Level

The noise perceived in open spaces can have different effects on people and depends on the origin and intensity with which it manifests itself. The proximity to more or less busy road systems, airports, or other infrastructures can determine conditions of discomfort that tend to drive users away. Reducing noise levels in cities is critical to improving public health and quality of life. An example of possible measures that contribute to the reduction of noise levels in cities is the use of noise-reducing materials in road surfaces, such as porous asphalt or rubberized pavement, which can decrease the noise caused by tire friction. This approach has been adopted in cities like Los Angeles, *Leicester*, and Tokyo, where quieter roads improve both traffic flow and residential comfort. The installation of noise barriers along highways or railways can allow the reduction of sound transmission into residential areas. These barriers are made from various materials, such as glass, wood, or even vegetated barriers, that combine noise reduction with aesthetic and environmental benefits [16]. Vegetation acts as a natural sound barrier, particularly in dense urban areas; gardens and green roofs as well as green walls along busy streets help to reduce noise and provide residents with quieter public spaces [17].

2. Definition of Regenerative and Biophilic Design

“Building nature”, from the urban scale to the detailed one, is a regeneration strategy aimed at restoring degraded ecosystems, mitigating the effects of climate change, and sequestering CO_2. The lack of extensive vegetation in the built environment also entails the loss of a natural means of cooling through evapotranspiration, which must be restored and enhanced.

Cultivating a design culture in which "plant material" can be integrated as a structuring component of the regeneration process (technological green) means working with nature by exploiting both the potential of biomimetics (i.e., designing inspired by nature) and the biophilic design (i.e., inserting nature into design) connected to it, to promote well-being and "comfort in inhabited spaces".

This design approach, that insists on the need to regenerate urban spaces by re-naturalizing them, i.e., building urban nature intercalations, has seen the proliferation of distinct schools of thought for many years, diversified above all by their territories of origin in geographical and cultural terms. A regenerative process of urban spaces in geographical areas of the Mediterranean basin will, in fact, be different from a renaturation process in Nordic countries and even more so in continental geographical areas, but what they have in common at a global level is the need to respond quickly to the environmental challenges of our time. In support of this thesis there is in fact a substantial literature in the sector that our research activity has explored, starting from the concepts linked to the disciplinary tradition of environmental design, up to evaluating the new frontiers of contemporaneity.

It is important to underline that those procedural and systemic aspects of urban renaturation through the dissemination of technological greenery, which translates into all the declinations in which vegetation can "contaminate" the architectural elements of an urban space, go well beyond the traditional methods of intervention for the redevelopment of the built environment, as addressed in the last twenty years. Rather, they imply the initiation of broad and multifaceted transformative processes that simultaneously include urban, social, and economic measures that are technologically appropriate, therefore not only the design of roof gardens and garden walls but also the study of biophilic systems that also use blue technologies (water mirrors and rain gardens) to be inserted into the travel systems and urban voids, thus designing new itineraries structured by biological organisms with notable sensorial perceptions that are healthy, but also attractive in terms of valorizing local environmental resources.

It is important to emphasize that regenerative design and biophilic design are two distinct but complementary approaches in the field of sustainable design. The main differences can be summarized as follows:

Objective: aims to restore and improve ecosystems and communities, not only by reducing environmental damage, but also by actively contributing to the health of the planet.

Approach: is based on ecological principles and seeks to create systems that are sustainable in the long term, promoting biodiversity and the responsible use of resources.

Applications: includes practices such as regenerative agriculture, urban design that integrates green spaces, and infrastructure that support natural cycles.

Biophilic Design

Objective: focuses on integrating nature into built spaces to improve human well-being and quality of life.

Approach: uses natural elements, such as natural light, vegetation and organic materials, to create environments that foster a connection with nature.

Applications: it is common in architecture and interior design to improve the mental health, creativity and productivity of occupants.

In summary, while regenerative design aims to restore and regenerate ecosystems, biophilic design focuses on enhancing the human experience by connecting with nature. Both are important for a sustainable future, but they approach the problem from different angles, for while regenerative design focuses on repairing and improving ecosystems and communities, biophilic design focuses on improving the human experience through the integration of nature into built spaces. Both represent an evolution from traditional design practices, which often do not consider the long-term impact on the environment and human well-being.

2.1. Technical Solutions for Environmental Greening: Examples and Case

Among the examples of urban greening with a biophilic approach in Europe, the case of Vitoria-Gasteiz, in Spain, "European Green Capital 2012", has been studied (Figure 11). Here, in relation to the social dimension, we are in the presence of a strongly cohesive local community, with a deep-rooted sense of belonging and a strong identity, particularly active in defining the choices for the transformation of the city. One of the most important biophilic projects was the naturalization of the Green Ring, consisting of the system of peri-urban green spaces formed by the parks of Armentia, Salburua, Olarizu, and Zabalgana and the related interconnections that allow the integration of the urban fabric with the surrounding natural heritage, thus promoting relationships between urban green spaces and the green spaces of the agricultural area. This strategy is particularly adaptable to many internal Sicilian villages morphologically immersed in the surrounding nature. Of particular interest is the naturalization of the main axis that creates an impressive green area, where the stream creates a biodiversity hotspot in the center of the city.

Figure 11. Top left: the Superillas in Madrid; right: the Caixa Foum in Madrid by Patrick Blanc; bottom: the project in Vitoria-Gasteiz, Spain.

Another emblematic example of urban transformation with a biophilic approach is the case of Barcelona. The municipality of Barcelona is adopting an urban regeneration policy based on greening. The *superillas* (in Catalan, "super islands") are super blocks of nine blocks, within which the space, until now occupied by cars, would, after the intervention, be dedicated to pedestrians and cyclists. The scheme of these particular urban islands is the idea of Salvador Rueda, urban planner and director of the Agencia Ecologia Urbana de Barcelona. The project, supported by the former mayor of Barcelona Ada Colau, is underway: four streets in the Eixample will be converted into green pedestrian axes, street furniture will be installed along the routes, and vegetation will be placed that will occupy 12% of the space, thanks to the planting of 400 trees and 8000 cubic meters of shrubs. Barcelona is now a representative example of environmental planning with a biophilic approach that can be perfectly extended to the Mediterranean basin and beyond.

In terms of urban greening systems and tools for habitat regeneration, research has also explored the use of blue technologies through the study of specific linear or sinusoidal gardens, bioswales, rain gardens, and biophilic elements to be inserted along pedestrian walkways and urban voids in the town of Naro.

The example shows a system designed by Laurie Olin to capture, filter, clean, and recycle rainwater from downtown Cambridge, Massachusetts: a landscaped basin containing plants, sand and boulders, placed on top of a large Silva cell storage basin, which ensures bio-filtration and prevents runoff water from entering the municipal sewer system. A system of water paths mixed with vegetation is in fact a useful strategy.

Another example analyzed is the Lubert Plaza project by Andropogon, at Thomas Jefferson University in Philadelphia. The square effectively manages on-site rainwater, including condensation from adjacent buildings' air conditioning, through infiltration, capture, treatment, and reuse for irrigation. From this perspective, biophilic urban regeneration should be understood as a cultural approach that can be extended to all territories in relation to the different peculiarities present in the different contexts.

3. Materials and Methods

As mentioned in the introduction, the present article reports the results of part of a more complex study named "Workshop Naro", which combined teaching, laboratory, and research activities that were carried out in the Master's Degree in Architecture at the University of Palermo. The general scope of the workshop was to provide the municipality administration of a Sicilian town, i.e., Naro, with innovative yet feasible urban and architectural regeneration suggestions. The whole activity was accomplished through the definition of thematic groups made of students, researchers, and professors, focused on a specific design area and goal. In particular, the present article regards the study accomplished by two thematic groups, i.e., Environmental Design and History of Architecture. The project site was chosen in order to have the opportunity to valorize an outdoor area featuring historical architectural and cultural value with greening and urban design solutions aimed at enhancing the urban comfort. Hence, once the project site was preliminarily analyzed from both the historical and environmental perspectives, in order to identify its strengths and weaknesses, the intended use of the area together with the concept design were proposed and, finally, the preliminary design drawings were elaborated.

The adopted method is represented in Figure 12 and outlined in the following section.

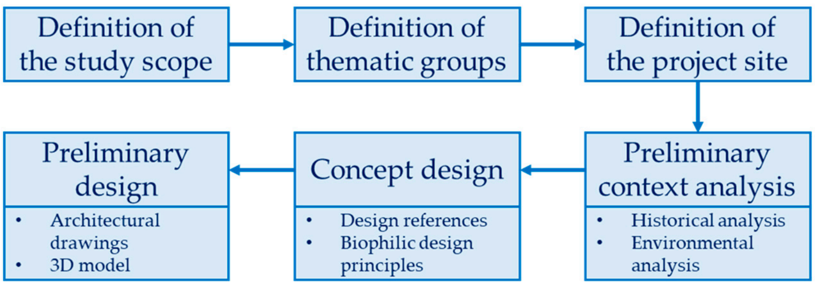

Figure 12. The design method adopted in the workshop.

Definition of the study scope: The general scope of the "Workshop Naro" was to renovate some key places in the town of Naro, in the Sicilian hinterland, and give them new value and identity, by empowering identified strengths and mitigating their weaknesses by introducing innovative yet feasible urban and architectural regeneration suggestions. In particular, the goal of the present study regards the redesign of an urban area, characterized by lack of identity and abandonment, through environmental solutions under the lens of the biophilic approach, toward improving the citizens' well-being and urban outdoor livability.

Definition of thematic groups: The "Workshop Naro" was organized to foster interactions and synergies among different research units and involve students in the design process. The workshop accounted for six thematic groups, which were aimed at assessing different peculiar aspects of the chosen municipality and designing related solutions (water cycle, waste treatment, sustainable mobility, urban environmental comfort, the area surrounding the main road axis, and urban voids). Thirty-one students from different degree courses (product design, architecture, urban design, built environment retrofit) enrolled in the workshop as an additional training activity of the architecture faculty of the whole program. The logic pursued to define the design groups' composition was, indeed, aimed at putting together students, researchers, and professors with different competences, skills, and approaches to work on the same issue, design area, and goal. In particular, the present article studies the collaboration of students coordinated by professors of Environmental Design and History of Architecture.

Definition of the project site: The municipality of Naro, with over seven-thousand inhabitants, economically relying on small industries and relevant agriculture activities, quite closed to the main city of Agrigento, and well-known for the baroque and medieval monumental architectures, was chosen as it is representative of a minor town in the Sicilian hinterlands. Such minor towns in less dense areas can be crucial in the transition towards environmental policies as they combine rural and urban features. In particular, the project site object of this study was chosen in order to have the opportunity to valorize an outdoor area featuring historical architectural and cultural value with greening and urban design solutions for enhancing the urban comfort.

Preliminary context analysis: To guide the students in the design process, a thorough preliminary analysis was carried out by students under the supervision of the professors and researchers. Once the project site was visited on-site and relieved, it was possible to identify its strengths (historical value, architectural monuments, connection system, presence of a garden) and weaknesses (abandoned status, lack of shadows, difficult use of the urban garden, poor uses, poor vegetation), two desk preliminarily analyses were carried out. First, the project site was analyzed from the historical perspective, by means of a literature review, with regard to the general urban context, the evolution of the area among the centuries, and the monumental landmarks, towards identifying noteworthy elements to be protected and valorized (see Section 4.1). Then, the project site was analyzed from the environmental perspective, by collecting statistical weather data and modelling the built environment shadowing in order to identify the climate opportunities and threats and guide the choice of the environmental design solutions (see Section 4.2). Concept design: To collect possible solutions to be integrated and adapted to the case study, students carried out a review of relevant case studies and best practices, i.e., architectural and urban design references, with a focus on urban staircases and urban gardens (Section 1.2). A targeted analysis concerned the assessment of the biophilic design approach (Section 2) in order to investigate how to increase environmental comfort through water and vegetation nature-based solutions. Hence, a concept design of possible solutions was developed by sketches and hand-made prospective views.

Preliminary design: Once the solutions were defined and the correct proportions were verified, students elaborated 2D and 3D architectural digital drawings of the identified solutions aimed at integrating the greenery, creating shaded areas for conversation or play, and adding a panoramic walkaway, until definition of materials to be used.

4. Results: The Pilot Case Study of Naro Municipality

4.1. Historical Analysis of the Context

The small town of Naro, in the Sicilian hinterland (Italy), presents, in its oldest core, material evidence of a significant centuries-long history. The monumental consistency of the historical-architectural heritage passes down the memory of periods of magnificence and prosperity known by the town, in alternating phases, especially between the 14th and 18th centuries. These testimonies concern in part the sphere of civil architecture, but above that of religious architecture, defining zones of power within an urban design that adapts to the orography of a site characterized by a marked slope.

Two monumental buildings, the castle and the mother church, both of medieval foundation, stand out in the highest part of the town, facing each other at a short distance (Figure 13), characterizing the urban image of Naro and dominating the remaining urban fabric, which has developed over the centuries along the slope of the hill site.

Figure 13. View from the castle of the old mother church in Naro.

Although local historiography dates the foundation of the oldest nucleus of the castle to the 9th century, at the time of Islamic rule, and that of the mother church to the 11th century, that is, at the time of the later Norman domination, for both buildings—over time heavily remodeled and stratified—the oldest parts, still recognizable, date to the 14th century [18,19]. It is precisely to the 14th century, in fact, that an early phase of development and increased importance of the town can be ascribed, especially after its acquisition by Matteo Chiaromonte in 1366 [20]. Other buildings provide further evidence of this, such as the church of Santa Caterina, among the few newly founded churches in the 14th-century Sicilian architectural context. It is characterized by a basilica plan with a strong longitudinal development and a sequence of very early Doric pseudo-columns, which could be indicative of a continuity with classical culture, even in the medieval period, that finds other significant parallels in the Agrigento area (as observed, for example, in the Chiaromonte palace in Favara [21]).

Another strong urban sign in the historical fabric of Naro is the present-day Via Dante, the main road artery that cuts longitudinally through the town, continuing beyond the limits of the route of the (no longer existing) walls that encircled the historic center. The formation of this street dates back to the 17th century and is closely linked to the arrival of the Jesuits in the city, for the foundation of their own college, in 1610 [22,23]. During the 17th century, the street would take on a growing monumental aspect, lining up along it several convent complexes and some noble palaces. In addition to the aforementioned Jesuit college (located more or less in the center of the monumental street), the imposing convent complex of the Dominicans, settled as well in 1610 [24], on the edge of the *intramoenia* city and at the hinge with its eastward expansion, is noteworthy [25]. Between the two religious complexes of the Jesuits and Dominicans, in an almost barycentric position, are the remains of another monastery founded for a community of Benedictine nuns. This is part of an 18th-century enlargement of the monastery, the so-called "Quarto nobile" [19], of which a single two-level quadrangular building remains—dwarfed at the top and lacking a roof—characterized by large corner pilasters decorated with rococo motifs directly carved into the stone.

The "Quarto nobile" portion of the building and the old mother church (in particular the original 14th-century facade, with its ogival portal decorated by the characteristic zigzag motif) are the two monumental terminals of a scenic, wide stone stairway, which is the main pedestrian and most direct link between the church in question and Via Dante.

The present configuration of the stairway can be traced back to the 18th century, although it lies on a route that was certainly of much earlier origin. By holding together one of the architectural cornerstones of the medieval town and the monumental street that characterizes the arrangement achieved by the same in the Early Modern age, the stairway possesses a relevant historical value, which makes it an urban place of particular interest for the development of a planning proposal that aims, among other things, at requalification and enhancement (Figure 14).

Figure 14. (**a**) View of the remains of the monastery of Benedictine nuns called “Quarto Nobile” and of the façade; (**b**) view of the old mother church; (**c**) view of the stairway connecting the old mother church with Via Dante.

4.2. Environmental Analysis of the Context

The municipality of Naro is located in the southern part of Sicily, Italy, at a latitude of 37°17′40″56 N and a longitude of 13°47′39″84 E, within the province of Agrigento, one the main cities in the island. The municipality of Naro extends for 207 square kilometers on a hill area, and is raised at an average of 484 m above the sea, while its altitude ranges from 128 to 612 m.

The town of Naro has a population of 7658 inhabitants, around four-thousand of which are women, with a density of 36.9 people per square kilometer. Its position makes its territory favorable for agricultural activities, mainly regarding viticulture (Figure 15).

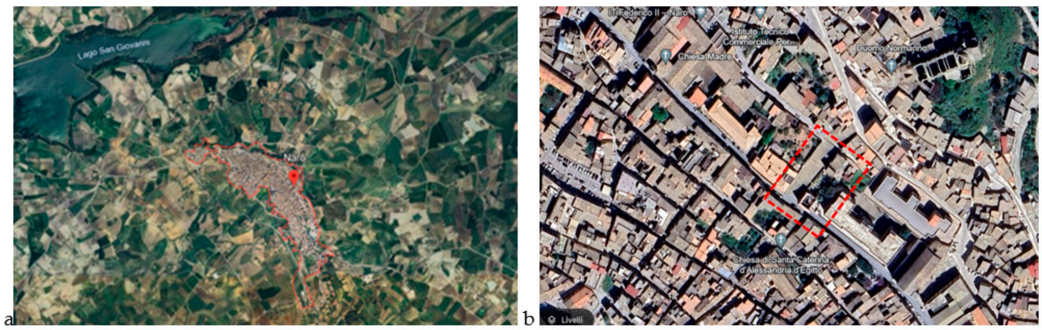

Figure 15. (**a**) Satellite view of Naro municipality; (**b**) satellite view of the project site (within the red box).

To accomplish the preliminary environmental analysis of the urban context project site, weather data should be collected from official weather stations (e.g., Aeronautics ones). It is worth noting that for this kind of assessment, at urban level, microclimate data are fundamental for ensuring an adequate and site-specific evaluation, especially for what concerns humidity ration and wind flows and considering orography and altitude impact.

Hence, in absence of environmental stations, continuous monitoring could be assured by relying on modern GIS-based technologies. Unfortunately, as Naro does not have its own weather station and the closest ones are in other municipalities with their weather and orographic peculiarities, i.e., Agrigento and Gela, it was not possible retrieve official weather data files of Test Reference Years (TRY) and analyze them with the tool Climate Consultant [26]. Hence, weather data for Naro were collected from the online resource Weatherspark [27], which provides mean weather data elaborated based on statistics from a 36-year timespan (1980–2016) from close weather stations (i.e., Palermo, Enna, and Gela), corrected considering the different altitude, and the application of weather prediction models. This source has been already used by the present research group for other towns in the Sicily region, as a higher data reliability was observed compared to standard data sources referring to other cities with different orography and wind flows (e.g., TRY).

In particular, charts about temperatures, people comfort sensation related to relative humidity, winds direction and speeds, and rains were collected, analyzed, and compared.

According to the Koppen–Geiger weather classification [28], the town of Naro, and, in general, the south cost of Sicily, belongs to the "Csa" zone, i.e., a temperate climate characterized by hot, dry summers. Indeed, according to the collected mean temperatures data (Figure 16a), the winter temperatures in Naro range from 8 °C in February to 15 °C in November, while the summer temperatures from 19 °C in September to 27 °C in August, although higher temperatures (between 30 °C and 40 °C) can be detected more and more frequently.

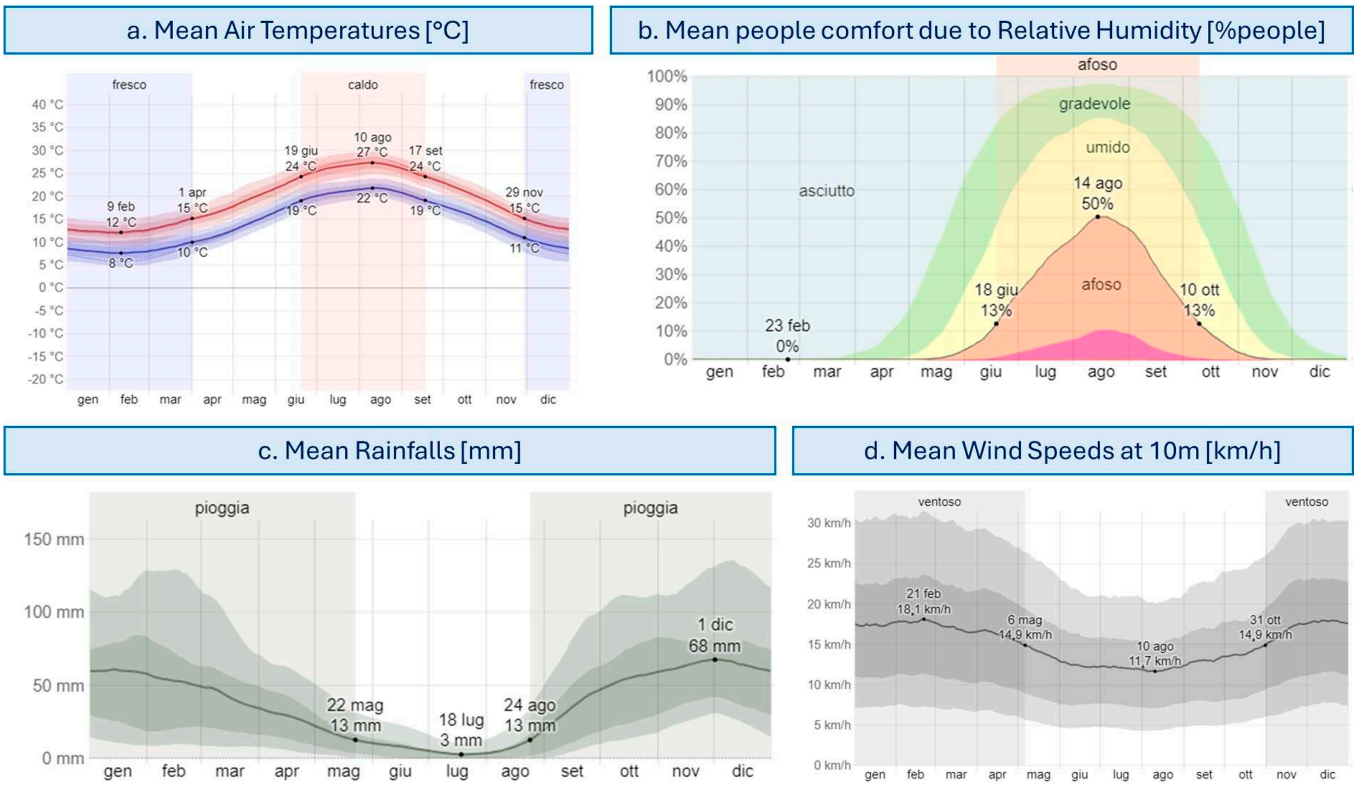

Figure 16. Weather data of Naro: (**a**) air temperatures, (**b**) people comfort due to RH, (**c**) rainfalls, (**d**) wind speed.

Hence, it can be concluded that Naro has a mild climate with hot temperatures in summer. Indeed, based on the Decree of the Republic President DPR n.412/93 [29], which divided the Italian territory into six climatic areas, i.e., from the hottest one in the South (A) to the coldest one in the surrounding of the Alps (F), it is possible to define the number of "Heating Degree Days (HDDs)" for the town of Naro and therefore the proper space heating systems settings. Hence, Naro has 1320 HDDs, putting it in the climatic zone C, which means that heating systems can be activated from 15 November to 31 March for no more than 10 h per day.

Regarding the relative humidity (RH) in Naro, from Figure 16b it can be noted that it has a great variation throughout the year, with the highest humid period from June to October, where 13% of people feel sweaty. Nevertheless, Naro is not a rainy area (Figure 16c): most rainfall occurs from September to April, with a probability of just around 17% of rain per day. On average, November and December are the rainiest months, with only around 10 days with rainfall, while July is the lowest one, with 0.6 days.

Lastly, Naro is quite a windy area, as reported in Figure 16d. In detail, the windiest month is February with 17.9 km/h and in general the coldest months are also the windiest ones; in spring and summer the wind has a lower speed with 11.0 km/h in August. Regarding direction, the prevailing ones are West and North.

Moreover, to investigate the impact of solar radiation on the project site and possible needs in terms of blinding elements, the presence and location of vegetative and architectural elements was assessed. Thanks to the online resource Google Earth [30], it was possible to accomplish a qualitative analysis of the vegetation presence that highlighted the existence of few medium-size trees in the gardens adjacent to the staircase which are not responsible for relevant shadowing on the staircase itself, but potentially represent a cooler area to take rest in daytime (Figure 17). In addition, thanks to the online resource ShadowMap [31], which reports buildings in 3D and shadows, together with the sunchart, it was possible to plot the building shadows in the project site.

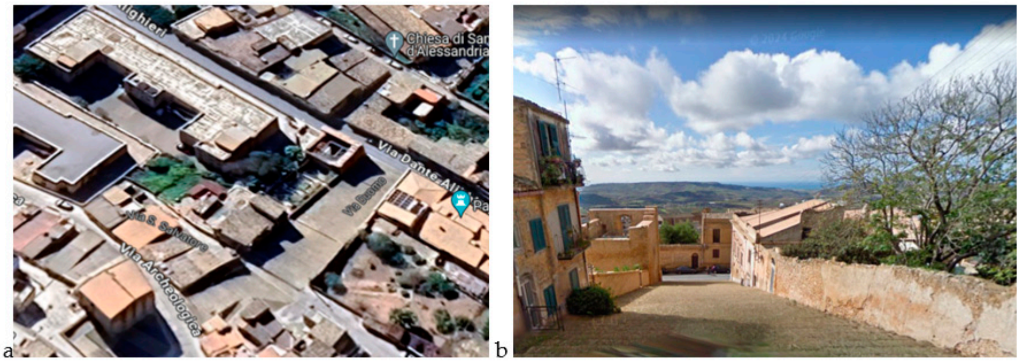

Figure 17. (**a**) 3D Satellite view of the project site; (**b**) street view from the top of the project site.

Shadows should be analyzed and compared with reference to at least three seasons (namely winter, summer, and a mid-season) and at least three daily periods (namely morning, noon, and afternoon).

As an example of the complex analysis, in Figure 18 the shadows relative to four daily times (morning, noon, afternoon, and evening) in summer, as the most demanding period in terms of comfort (highest temperatures, low wind, and high relative humidity), are reported. It can be noted that the staircase is mainly affected by high sun radiation from noon to the afternoon.

This overall environmental analysis was essential to set a matrix of needs as a starting point for defining the concept design criteria to be addressed for enhancing the urban comfort in the design phase.

4.3. Proposed Solutions: The Urban Greening Intervention for via Duomo in Naro

Given the particular morphology of the environmental and landscape context of Naro and the objective assumptions of environmental regeneration, the greening project studied for Via Duomo becomes as necessary as it is natural and appropriate. In this village, the large stairways branch off from the main axis of Via Dante, rich in architectural attractions, where the areas are exclusively dedicated to pedestrians. In particular, the stairway of Via Duomo stands out for its innate architectural, historical, and landscape monumentality. Here, the urban greening project has the task of bringing together different instances of environmental regeneration and the enhancement of local identities (Figure 19). Via Duomo is revisited as a significant place where it is possible to build an integrated identity itinerary in which the enhancement of the local architectural heritage (recovery of the fourth canto) is combined with a necessary regeneration of the built environment (redevelopment of the body of the stairway, recovery of the building curtains, design of rest and refreshment areas with a strong landscape connotation).

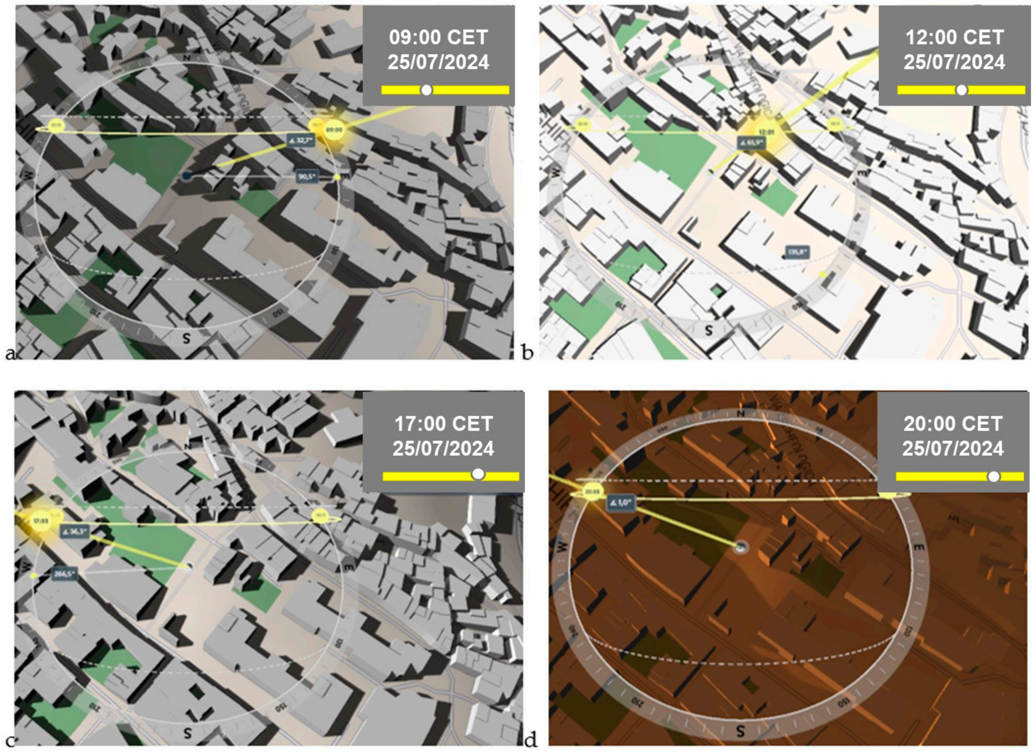

Figure 18. (**a**) Sunchart of the project site in four exemplary daily times: (**a**) 9 AM, (**b**) 12 AM, (**c**) 5 PM, (**d**) 8 PM.

Figure 19. Via Duomo—the green perspective: an integrated vision for Naro.

The greening intervention requires adopting a holistic approach to sustainability and raising its benchmark. With this perspective, the emerging notion of "regenerative" design and development with a biophilic approach is emphasized both as a co-evolutionary relationship between humans and the natural environment, and as an action aimed at enhancing the environmental and social capital of the settlement context (Figure 20).

Figure 20. Greening of Via Duomo: analysis of building curtains and use of green technology.

The use of technological greenery in Naro was in fact evaluated and designed also due to the large percentage of impermeable surfaces (building facades, roads, sidewalks) and the lack of extensive vegetation both on Via Duomo and throughout the town center (Figure 21). This involves, in addition to the loss of a natural means of cooling by evapotranspiration, interesting especially in the summer season, the loss of a useful contrast to the increase in temperatures generated by the same human activity and by air pollutants (Figure 22). The absence of vegetation, in fact, causes a greater accumulation of smog that endangers human health and the environment: "the presence of vegetated surfaces can instead counteract its effects both in terms of comfort performance at a local level and in terms of environmental sustainability at a global level" [32].

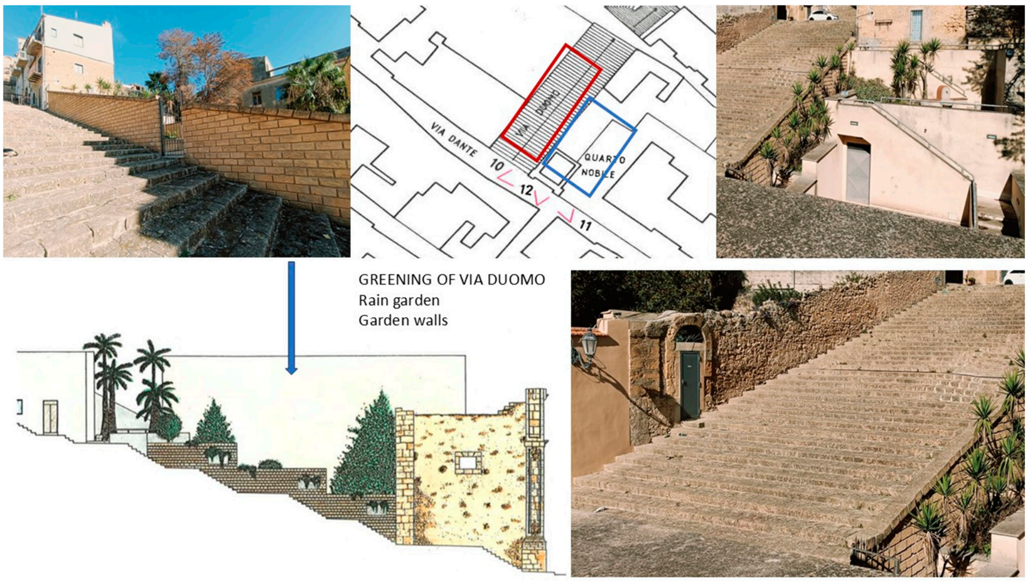

Figure 21. Greening of Via Duomo—section of the "Quarto Nobile": fences, thresholds, borders.

Figure 22. Greening of Via Duomo: rain garden, roof garden, and garden walls.

The project of Via Duomo also consists of an in-depth study on accessibility which involves the walking and parking areas, the threshold points, and the downhill and uphill hinges, and a study on the use and construction of real green islands integrated into the surrounding landscape. In particular the design actions were aimed at:

- Improving urban accessibility;
- Stimulating the sense of belonging to the neighborhood/locality and positive social behaviors;
- Offering cultural and tourist facilities aimed at promoting contextual economies;
- Redevelop and enhance the axis of via Duomo with:
- The arrangement of the staircase and the paths on the edge;
- The dissemination of technological greenery;
- The recovery of building curtains through the use of green walls and hanging gardens.

The aim was to integrate public space with private, through open-air courtyards, porticoes, and green shelters at various levels which will host barrier-free walkways, accessible and permeable in every direction.

This leads to reconsidering the streets as places, rather than simple spaces for movement, in which to create rest areas, islands, and green peninsulas by adding biophilic elements integrated with street furniture.

In particular, the technological solutions proposed are as follows:

(1) Green roofs: vegetation coverings that can vary from simple herbaceous plants to complex gardens with shrubs and small trees. For the regeneration of Via Duomo and in particular for the present building curtains, extensive green roofs are indicated, which are lighter and require less care than intensive green roofs, which require more maintenance and a more robust structure.

Identified technologies and materials:

- Drainage systems: specialized layers to ensure that excess water drains away without damaging plant roots;
- Substrate layers: light soil mixtures that support plant growth, provide nutrients, and facilitate drainage;
- Selected plants: drought-resistant species and local vegetation which reduce the need for irrigation and maintenance.

The benefits to be achieved are related to:

- Improved thermal insulation of buildings;

- Reduction of the urban heat island effect;
- Filtration of air and reduction of rainwater runoff.

(2) Vertical Gardens: green walls to be integrated into the exteriors of buildings, consisting of a support system for plants, which can climb or be installed in vertical containers.

Technologies and Materials:

- Support structures: grids or modular panels that support plants and allow easy installation;
- Automated irrigation systems: drip or mist irrigation networks that provide water efficiently;
- Substrate systems: lightweight materials that can hold nutrients and water, keeping plants healthy.

The intended benefits are related to:

- Improved air quality (by absorbing CO_2 and releasing oxygen);
- Improved acoustic and thermal insulation;
- Improved visual impact and well-being of inhabitants.

(3) Other Greening Design Solutions:

a Green infrastructure: integration of green spaces such as parks, flowerbeds, and waterways;
b Rainwater harvesting systems: from roofs and impermeable surfaces for reuse, reducing drinking water consumption;
c Composting systems: to reduce organic waste and produce natural fertilizer.

The implementation of greening design solutions, therefore, offers numerous environmental and social benefits. These technologies not only improve the aesthetics of urban spaces, but also contribute to a healthier and more sustainable environment, representing a significant step towards a greener and more resilient future.

4.4. Proposed Solutions: Preliminary Design

The project area on which it was decided to intervene in the workshop activities concerns the steps of Via Duomo, with particular reference to the small hanging garden that is located about halfway along the route, adjacent to the "Quarto Nobile". This space, which was the subject of an intervention in 2013, is separated from the steps by a two-meter-fifty high wall, whose only access point is a small gate on the steps and is divided into three levels connected by stairs with flowerbeds and a small fountain. The original design idea was probably to restore a public green area, with some technical spaces in the volumes resulting from the change in height. In current reality, the access gate is always closed and the wall clearly separates it from the path of the steps, blocking the view of the hanging gardens, which are mostly made up of small flowerbeds of uncultivated greenery.

It is also noted that the spaces of both the "Quarto Nobile" and the hanging garden are completely inaccessible to those with mobility difficulties.

The project therefore aims to give back to the community a space that is currently closed and inaccessible.

In order to identify some design references for which to draw inspiration, some examples of projects created to enhance urban spaces similar to the steps of Via Duomo were identified. These references were used to understand which functions and services could be integrated to improve the comfort and livability of the steps in the winter and summer seasons. Following the environmental analysis, some removable wooden shelters with removable platforms were designed in order to create rest areas along the steps where people could shelter from the sun and where they could find comfortable seats to converse. The shelters with platforms are located in correspondence with the hanging garden, constituting almost an "extension" or an "invitation", as the existing dividing wall in the project is eliminated and replaced by a glass parapet that allows the visual and functional continuity of the spaces.

From the staircase, there is direct access to the hanging garden, which is enriched with greenery and furnished with seats, a children's play area, a drinking water point, and a fountain with a water feature. Accessibility is guaranteed by an oil-dynamic lift that starts from the level of Via Dante and allows access to the various levels. At the highest level of the garden, an aerial walkway in wood and glass allows you to reach the panoramic area of the noble quarter, from which you can enjoy the view of the entire valley.

The choice of natural materials, such as wood and glass, aims to achieve greater integration of the intervention into the historical urban context. The possibility of dismantling the platforms and shelters, which can be stored in the existing technical rooms under the hanging gardens, allows the use of the staircase to not be altered during the processions and religious events that take place annually, keeping its image and functionality intact.

Outside the green area of Via Teatro Vecchio, a fountain and benches shaded by a flowerbed and a flowered shelter are inserted. Higher up, where the upper staircase continues after Via Archeologica, the pedestrian space is enriched with similar coherence by the addition of a small fountain and a flowerbed positioned on the left under the staircase.

The 2D architectural drawings and 3D model views of the designed intervention are reported in Figures 23 and 24, respectively.

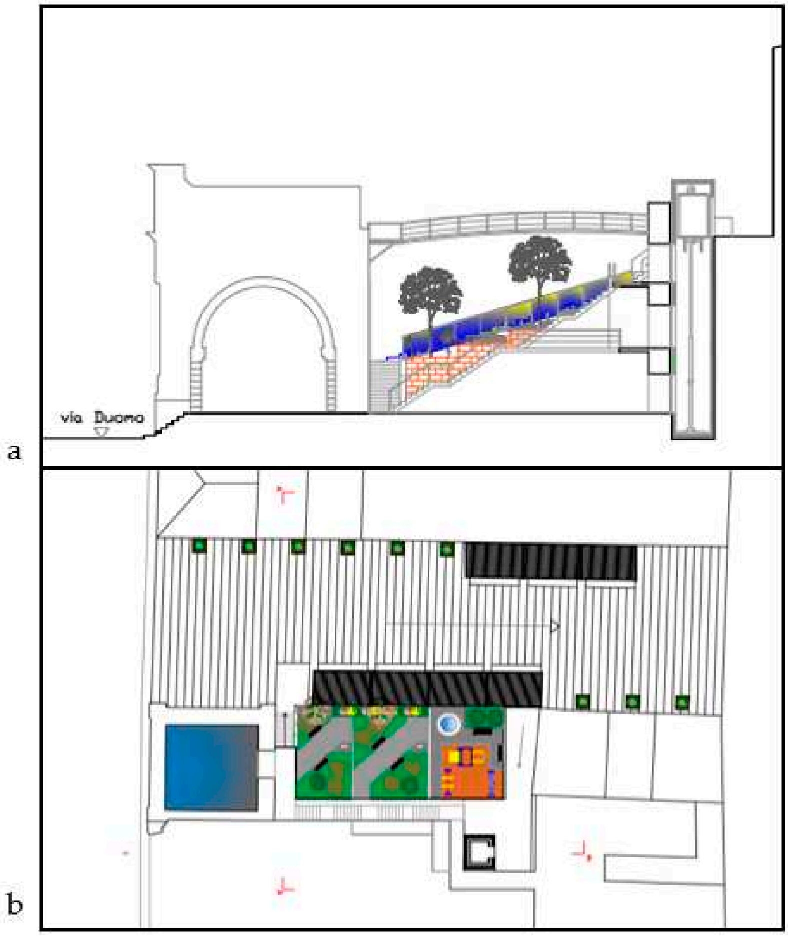

Figure 23. Architectural drawings of preliminary renovation design. (**a**) section; (**b**) plan.

Figure 24. 3D model of the preliminary renovation design made by the student F. Grammauta: (**a**) view of the staircase from the top, (**b**) view of the staircase from the inner garden, (**c**) view of the inner garden from the staircase, (**d**) view of the staircase from below.

5. Conclusions

The NARO project aimed to experiment with an "alternative green policy", testing models and technological systems based on the adoption of a biophilic approach, capable of improving the comfort of urban space and the health and well-being of inhabitants.

For greening operations, interactions between the use of forms, materials, and technologies came into play through which it was possible to identify "weak mitigation" works on the basis of performance indicators, environmental parameters, and functional requirements. This led to the experimentation of interconnected networks of green spaces and blue infrastructures at the scale of the urban environment, and technological solutions at the building scale: roof gardens and garden walls.

In this context, the progress of research has made it possible to reach an important critical mass on the topic and to develop, in an incremental manner, each area of the different contexts of action, from the environmental context to the urban space, up to the street furniture products, designed according to an advanced logic with respect to the basic need–performance analysis.

In parallel, the urban greening process aimed to evaluate the intrinsic potential of regenerative ecological design approaches to create the necessary and timely changes in improving outdoor and indoor performance.

A first positive assessment of the research opens up new interdisciplinary perspectives and at the same time highlights its limits and critical issues. If, on the one hand, the aim of the research was to test replicable biophilic design solutions, it was, on the other, understood how it is necessary to cultivate greater areas of sharing with the ecology sectors, exploiting the individual strengths to project oneself into a future of change in continuous and sensitive symbiosis with nature [32].

The greater presence of greenery, the attention to accessibility routes, and the presence of shaded rest areas and children's play areas, in fact allow the improvement of the livability of the spaces for citizens, meeting the needs that have been identified.

The biophilic approach adopted in the design of spaces and in the integration of the new into the existing context, aims to give a concrete contribution to the improvement of urban comfort, also enhancing the quality of public spaces through the design of greenery [33].

In conclusion, the regenerative and biophilic design project focused on creating spaces that are not only sustainable, but actively contribute to human well-being and healthy ecosystems. It emerged from the literature that research in these areas is crucial to develop innovative approaches that address the challenges of our time and promote a greener and more resilient future [34]. Future prospects are therefore very promising, as more and more planners recognize the importance of these approaches in addressing contemporary environmental and social challenges [35,36].

A new perspective could be also offered by the application of Artificial Intelligence (AI) in urban planning to improve the accuracy of environmental designs and forecast critical urban factors like air quality, traffic patterns, and energy consumption. AI-based tools like CityFormLab's Urban Planning Tool are used to optimize building designs and urban layouts, considering factors such as sunlight exposure, wind flow, and energy consumption [37]. Cities like Madrid and New York already use AI to model and predict the urban heat island effect; through the combination of satellite data with AI algorithms, urban planners can forecast temperature spikes in specific areas and plan specific mitigation interventions like cool pavements or green roofs [38,39]. In a follow-up of the Naro project, it could be applied to verify the efficacy of the preliminary design.

Considering that the interest in human well-being will continue to grow in the near future, perspectives will mainly focus on the following themes:

Return to nature and human health: development of projects that integrate nature into public and private spaces that can have a significant impact on people's mental and physical health.

Complex systems and holistic approach: the adoption of systemic approaches that consider the interconnection between natural, social and economic ecosystems will be fundamental. This requires interdisciplinary work between planners, ecologists, urban planners and local communities.

Integration with digital technologies: the use of digital tools, such as 3D modelling, augmented reality, and data analysis, can improve the design and implementation of regenerative and biophilic solutions, enabling more accurate simulations and the continuous improvement of projects.

With this in mind, as part of the research activity carried out for the Naro area, the working group identified five areas on which future studies should focus:

Study of urban ecosystems—researching how regenerative design solutions can improve urban biodiversity and ecosystem functioning. For example, analyzing the impact of green roofs and vertical gardens on local fauna;

Monitoring and evaluation systems—develop methods to monitor and evaluate the effectiveness of regenerative and biophilic solutions over time, including indicators of environmental, economic and social sustainability;

Sustainable and innovative materials—research new materials and technologies that can improve the ecological performance of buildings, reducing environmental impact and promoting the use of renewable resources;

Education and community involvement—investigate strategies to educate and involve local communities in the design and implementation of regenerative and biophilic projects, promoting a sense of ownership and responsibility towards the environment;

Impact on public policy—analyze how public policies can encourage or hinder the adoption of regenerative and biophilic design practices, promoting best practices for effective policy decisions.

Finally, research on the Naro area highlights the importance of an integrated approach to addressing environmental challenges and improving urban quality of life, offering a strategic framework to promote regenerative and biophilic solutions. Investing in these areas will not only help preserve biodiversity and optimize the use of resources, but also create more resilient and sustainable communities, capable of responding effectively to the environmental pressures of the future. Effective collaboration between researchers, local administrators, and citizens will be essential to translate these project ideas into concrete and lasting action.

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