Chapter

Models and Strategies for the Regeneration of Residential Buildings and Outdoor Public Spaces in Distressed Urban Areas: A Case Study Review

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Abstract

Given three-quarters of the European population living in urban areas, cities are expected to deliver sustainable growth if they will be able to further thrive and grow, while improving resource use and reducing pollution and poverty, as highlighted also by Sustainable Development Goal 11. In the context of vulnerable and marginal areas within cities, which suffer from multiple deprivations, regeneration processes at the building and district-scale play the most significant role in making cities more inclusive, sustainable and resilient. Reuse and refurbishment strategies, measured building replacement and stratification, redevelopment and enhancement, nature-based solutions and bioclimatic technological devices, are all tools for an integrated regeneration process capable of stimulating the urban metabolism and act as a driving force for the self-regeneration of the city. A comparison of two different building typologies, brought about by a review of existing public housing case studies in the outskirts of Rome, Italy, allowed us to define efficient, sustainable strategies and guidelines, that can be adapted to similar contexts in terms of building typology, social and economic conditions and of relationship to the rest of the city.

Keywords: urban regeneration, distressed urban area, sustainable technologies, public housing, energetic retrofitting

1. Introduction

The 2030 Agenda adopted by the United Nations General Assembly in 2015 and defined by the subscribing members as "a plan of action for people, planet and prosperity" has identified 17 goals in order "to take the bold and transformative steps which are urgently needed to shift the world onto a sustainable and resilient path" [1]. The goals refer to different fields of social and economic development and must be addressed through an integrated approach, aimed at achieving sustainable progress. The United Nations Inter Agency Expert Group on SDGs (UN-IAEG-SDGs) has developed 169 global targets, and 234 indicators that have to be monitored—as a global reference framework—in the period 2015–2030. In particular, Goal 11 deals with the urban sustainability issue and emphasizes how cities play an essential role in achieving the Sustainable Development Goals since half of the world population and three-quarters of the European population live in urban areas. All over the world, cities are responsible for the largest share of energy consumption and carbon emissions, for the growing pressure on the environment and the related public health issues [2].[1] The governance of urban space, therefore, represents a crucial development factor capable of posing worldwide challenges and opportunities. Several aspects must be considered in a systemic, inclusive and integrated way to ensure that cities thrive in a sustainably. It is vital to ensure that the population living, working or passing through the city has access to mobility, quality housing and safe conditions, both in terms of structural stability of public and private buildings and infrastructures, and protection from crime, violence and harassment.

Moreover, the presence of green spaces and public spaces, the protection of the cultural and natural heritage, the redevelopment of run-down areas, the relationship between the city and peri-urban and rural areas are as crucial as the aspects mentioned before. Yet, to be able to proceed in this direction it is essential to work according to an integrated approach that addresses the physical and structural aspects of the city, as well as the intangible ones. These last ones range from social and cultural aspects to those related to work and local economies, within broader processes that activate latent or already existing projects and social energies, which very often require policies from below. This process has already been triggered with the 2007 Leipzig Charter together with the related integrated urban development strategies that at a national, regional and local level focused on the cultural and architectural qualities of cities, conceived as strong tools for social inclusion and economic development useful to positively affect economic prosperity, social balance and the environment, within a coordinated process between spatial, sectorial and temporal aspects of urban areas. This process continued with the Toledo Declaration of 2010, which suggested a transversal, multidimensional and holistic design approach to achieve multiplying, complementary and synergistic effects, solving conflicts and finding the right balance between temporal (short, medium, long term) and spatial (region, metropolitan area, city, neighborhood) needs. These recommendations are reiterated and strengthened in the newborn Renovation Wave strategy, part of the European Green Deal promoted by Brussels which places the redevelopment of the building stock in a relevant position as an essential measure for decarbonization and reduction of emissions and as a tool for boosting the economy and European competitiveness. The new Renovation Wave strategy aims to double the urban regeneration rate, currently at 1%. According to Brussels estimates, a significant share of 35 million renovated and regenerated buildings could be reached by the end of the decade [3]. This situation would lead not only to significant ecological and energy benefits, but also to social ones considering that a recent report on sustainable recovery asserts that building renovation offers the greatest employment leverage: 12–18 local jobs for every million investments. This potential would create by 2030 as many as 160,000 new jobs in the EU construction sector [4].

More specifically, the Renovation Wave strategy will prioritize action in three areas: decarbonization of heating and cooling; tackling energy poverty and energy inefficiency; renovation of public buildings (schools, hospitals and offices). It will do so through several measures that make energy redevelopment operations easier

[1] There are various estimations of urban consumption of energy and related emissions. According to the World Energy Outlook (November 2008) http://www.worldenergyoutlook.org/index.asp, much of the world's energy is consumed in cities. Cities today house around half of the world's population but account for two-thirds of global energy use. Because of their larger consumption of fossil fuels, cities emit 76% of the world's energy-related $CO2$).

and faster.[2] "The green recovery starts from home," said Energy Commissioner Kadri Simson, "with this initiative we will face the numerous obstacles that today make the restructuring complex, expensive and slow, slowing down many necessary interventions" [5].

Furthermore, the recent COVID-19 emergency sets before us a new vision of residential heritage, having highlighted its limits—in particular those of the public residential heritage. Therefore, urban regeneration offers the opportunity to rethink housing models. Today, more than ever, the challenges posed by epidemiological and climate changes bring to light more intangible realities which are more oriented towards generative social action. These realities require the involvement of actors, not only of the construction sector but also of the local community through the implementation of complex and long-lasting social projects, which must be designed to support first of all the most vulnerable groups.

2. Italian intervention policies

In Italy, the evolution of the concept of urban regeneration can be re-read within the relevant legislation, that marks the transition from the concept of recovery to the concept of rehabilitation, within the legislation presented and approved in the period

[2] The EU must adopt an encompassing and integrated strategy involving a wide range of sectors and actors based on the following key principles:—'Energy efficiency first'8 as a horizontal guiding principle of European climate and energy governance and beyond, as outlined in the European Green Deal9 and the EU strategy on Energy System Integration10, to make sure we only produce the energy we really need; – Affordability, making energy-performing and sustainable buildings widely available, in particular for medium and lower-income households and vulnerable people and areas; – Decarbonization and integration of renewables11 . Building renovation should speed up the integration of renewables in particular from local sources, and promote broader use of waste heat. It should integrate energy systems at local and regional levels helping to decarbonize transport as well as heating and cooling; – Life-cycle thinking and circularity. Minimizing the footprint of buildings requires resource efficiency and circularity combined with turning parts of the construction sector into a carbon sink, for example, through the promotion of green infrastructure and the use of organic building materials that can store carbon, such as sustainably-sourced wood; – High health and environmental standards. Ensuring high air quality, good water management, disaster prevention and protection against climate-related hazards12, removal of and protection against harmful substances such as asbestos and radon, fire and seismic 8 See Article 2(18) Governance Regulation (EU) 2018/1999: "'energy efficiency first' means taking utmost account in energy planning, and in policy and investment decisions, of alternative cost-efficient energy efficiency measures to make energy demand and energy supply more efficient, in particular by means of cost-effective end-use energy savings, demand response initiatives and more efficient conversion, transmission and distribution of energy, whilst still achieving the objectives of those decisions". 9 The European Green Deal, COM(2019) 640 final. 10 Powering a climate-neutral economy: An EU Strategy for Energy System Integration, COM(2020) 299 final. 11 This refers to energy from renewable sources produced on-site or nearby. 12 Climate resilient buildings mean that the buildings are renovated to be resilient against acute and chronic climate-related hazards relating to temperature, wind, water and solid mass, as appropriate. A complete list of such hazards is included in Table 1 of Annex I of Commission Implementing Regulation (EU) 2020/1208. 4 safety. Furthermore, accessibility should be ensured to achieve equal access for Europe's population, including persons with disabilities and senior citizens—Tackling the twin challenges of the green and digital transitions together. Smart buildings can enable efficient production and use of renewables at the house, district or city level. Combined with smart energy distribution systems, they will enable highly efficient and zero-emission buildings.—Respect for esthetics and architectural quality. 13 Renovation must respect design, craftsmanship, heritage and public space conservation principles.

between the 90's and the early 2000s. Indeed, national legislation moves from integrated intervention programs to urban redevelopment programs (L. 179/1992); from urban recovery programs (L. 493/1993) to district contracts (D.M. n. 1071–1072, del 1° dicembre 1994); from urban regeneration and sustainable development programs (D.M. dell'8 ottobre 1998) to urban rehabilitation programs (L. 166/2002).

It is precisely the building and urban rehabilitation programs (L. 166/2002) that introduce, alongside the concept of transformation of physical space, that of performance, especially linked to the concept of efficiency, taking into consideration also economic and social issues, including physical deterioration. In 2015, all these experiences led to the *Piano nazionale per la riqualificazione sociale e culturale delle aree urbane degradate* (national plan for the social and cultural redevelopment of deteriorated urban areas), where the concept of rehabilitation gained, within the concept of redevelopment, the meaning of quality not only of the physical heritage, but also of the intangible one. Still, in Italy, the concept of urban regeneration has been introduced only in recent decades, addressed by national and local policies (regional legislation) as a matter of territorial governance ascribed to the concurrent jurisdiction of States and Regions. In these policies, a strategic vision from above based on urban planning and programming comes along with a bottom-up regeneration process of common goods which starts directly from the citizens. Within the 2007–2013 programming of structural funds, which conceived intervening on cities as one of the priority actions, the term urban regeneration was reinterpreted as an integrated approach to urban development, capable of overcoming the fragmentation and sectoral nature of interventions in this field. This approach has found further confirmation in the 2014–2020 fund programming. The urban regeneration issue can also be found related to the measures on land consumption and on reuse of built land, where the term is intended, above all, as the recovery of the existing building heritage (DDL. C.2039 "Containment of land consumption and reuse of land built "approved by the Chamber on May 12, 2016). In the Code of public contracts (D.Lgs. 50 del 2016) instead, we find the concept of urban regeneration combined with horizontal subsidiarity interventions (art. 189) and administrative bartering (art. 190), where social partnership contracts are introduced based on projects proposed by an individual or associated citizens.

In recent years, several regional regulations in the field of urban planning and construction have been introduced within the framework of urban regeneration with a strategic vision of territorial planning, implemented through complex plans and programs. Many regional regulations reveal that the regulatory concept of urban regeneration differs more and more from that of building recovery and urban planning, and is gradually including complex actions for the urban, environmental and social rehabilitation of degraded urban areas. Examples are the regional law of Emilia-Romagna (L.R. n.24, 21 dicembre 2017) on the protection and use of the territory, the regional law of Tuscany (L.R. n.65, 10 novembre 2014), which lays down rules for the government of the territory, the regional law of Lazio, (L.R. n.7, 18 luglio 2017) containing regulations for urban regeneration and building recovery, just to name a few.

The law L. n. 158 dell'8 ottobre 2017—containing measures for the support and enhancement of small municipalities, as well as regulations for the redevelopment and recovery of their historic centers—complies with the goals mentioned above, where the concept of regeneration takes on a connotation of territorial and environmental protection and where small municipalities are recognized as a resource due to their role as a territory presidium, especially about their role in contrasting hydrogeological instability and in preserving and protecting common goods.

Urban regeneration, which is gaining an important space in regional legislation, still struggles to find a precise definition in the national one, where it is addressed as an emergency measure by the D.L. 18 Aprile 2019, n. 32—" *Disposizioni urgenti per il rilancio del settore dei contratti pubblici, per l'accelerazione degli interventi infrastrutturali, di rigenerazione urbana e di ricostruzione a seguito di eventi sismici*" (urgent regulations for the relaunch of the public contract sector, for the acceleration of infrastructural interventions, urban regeneration and reconstruction following seismic events). The decree fosters the reduction of land consumption in favor of regenerating the existing building heritage by encouraging the redevelopment of degraded urban areas. Eventually, the unified text of the D.D.L. on urban regeneration, which is now under discussion, provides a state fund of 500 million euros per year until 2040 to co-finance regional tenders for the urban regeneration plans presented by the municipalities, thanks to an alliance between state, regions, municipalities and private individuals.[3]

3. Sustainable urban regeneration

In this context marked by a European policy strongly focused on energy saving and consumption reduction, the existing building stock and its redevelopment play an important role, especially the energy requalification of public housing (ERP) [6]. By public housing we refer to the residential real estate built, directly or indirectly, by the State, to be assigned, at particularly good economic conditions, to citizens with low incomes or who find themselves in poor economic conditions. The law regulating public housing identified three areas of intervention onto which allocate the available economic resources: subsidized housing of exclusive public ownership, assisted housing in property and/or with controlled rent and housing with agreements on surface or property rights. The fact that the European public housing heritage is plentiful and assorted, is a clear expression of the cultural and economic differences of our continent. In Europe, a significant share of the housing stock was built in response to the demand for housing following the Second World War. To date, more than 220 million buildings, representing 85% of the European building stock, were built before 2001. The majority of them are not energy efficient, as a result of old technologies and bad insulation—and account for around 40% of total European energy consumption and 36% of greenhouse gas emissions [3]. The physical (technical-functional), social and economic conditions of degradation that characterize the public building heritage demand the identification of immediate intervention strategies. The aim of the research is to show how certain strategies, in particular bioclimatic, modular and low-cost ones applied to the small building scale, can become the main tools for rehabilitating relevant parts of the contemporary city. For this reason, the research work described in this essay aims to give back urban quality to the suburban fabric which hosts public residential buildings through an architectural, energetic, bioclimatic and environmental requalification. This operation provides an attempt to read the peripheral palimpsest, through punctual and diversified interventions involving the description of the physical space, of the biophysical one and the understanding of bioclimatic phenomena, which cannot be separated from the understanding of the social space. Throughout

[3] Moreover, the text of the law provides also for the creation of a "database on reuse" of vacant and abandoned properties, for the right for Municipalities and Regions to raise taxes on unused or unfinished real estate units for over 5 years and for the possibility to resort to two-level design competitions. Finally, it provides for wide use of tax incentives (such as the superbonus, the eco-bonus or sismabonus) and for the establishment of a control room for urban regeneration meant to coordinate the interventions on different levels and to implement the national program goals, planned to be adopted within 4 months from the entry into force of the DDL.

the research, the role of the architect has been reconsidered as a social role that requires the ability to listen, interpret and explore the peripheral space, with the intent of setting shared and experimental assumptions to which reference can be made to overcome with the method and analytical scientificity the contradictions and conflicts of extended urban peripheries. Every overall transformation program, each detailed project is declined in this sense by associating several reinterpretations of the space and considerations on the possible scenarios of transformation, to develop, through a critical synthesis, an innovative conception of urban peripheral environment. This environment is meant to dialog with the consolidated city and to connect the redevelopment process to the cultural, social and technological transformations that affect society and urban form and that emphasize the need for new ideas, innovative models and relevant examples.

Overall, the analyses and evaluations of this research work start from the identification of the problems within the analytical phase and then explore the feasibility of intervention scenarios that can help to achieve greater urban quality. At the heart of the work, there are three research survey directions concerning:

1. The ability to measure oneself with the characters of the places and the territory;

2. An environmentally sustainable and energetically and ecologically efficient transformation-development;

3. The reconstruction-enhancement of the public space.

Given the first research direction, the operational strategic lines address:

1. The broadening of the analysis framework concerning the anthropic, bio-physical and bioclimatic factors to support the development of meta-project scenarios;

2. The optimization the control system of environmental components in the development phase of the intervention program-project;

3. The maximization of instrumental skills to verify the quality and eco-efficiency levels of the architectural project and urban reality;

4. The development of verification steps concerning the different degrees of quality and environmental sustainability to be assigned to the different phases of the project;

5. The optimization of systems for monitoring and controlling the behavior of outdoor, intermediate and confined spaces.

Regarding the implementation of the second research axis, the following operational strategic lines have been identified:

1. to optimize the specific conditions of mobility-transport connecting the periphery with the consolidated city;

2. to enhance-protect the local landscape-vegetation assets;

3. to enhance the soil conditions in terms of site orography, lithology and stratigraphy;

4. to optimize local hydrogeological conditions, considering rainwater runoff;

5. to introduce morphological-typological solutions aimed at integrating residential functions and extra-residential activities;

6. to organize and manage the material, energy and information flows at the district level;

7. to introduce innovative building solutions aimed at energy and ecological efficiency.

Finally, the third research axis aims at:

1. controlling and enhancing greenery in its role as a filter between environmental factors and functionality of outdoor spaces;

2. using outdoor spaces for meeting and social occasions within the general reorganization of paths and mobility;

3. enhancing the relationship between mobility, vegetation, bioclimatic and urban furniture in the design of in-between outdoor spaces;

4. maximizing psycho-perceptive comfort conditions related to the morphology of the intermediate outdoor spaces;

5. maximizing energy and ecological efficiency of the public space.

4. Sustainable technologies, hypotheses and solutions for two case studies in Rome, Italy

The case studies illustrated in the essay focus on the analysis and regeneration of two types of ERP multi-storey buildings, *in linea* (linear) and *a torre* (tower) blocks located in two different peripheral areas of the city of Rome.

The two-building typologies are taken into consideration using their similarities from an administrative and legal point of view and of their differences on a typological and environmental level and about their relationship with the context (**Figure 1**). The case studies analyzed are chosen to be representative of the respective building typology which recur in the ERP Roman context. The choice to study buildings located in peripheral areas is linked to the desire of investigating distressed urban areas [7], areas where it is even more urgent and necessary to intervene and where regeneration processes have a reorganization potential that transcends the architectural level and bring along positive effects on the socio-economic conditions of the inhabitants.

Specifically for the tower high rise building typology, an ERP condominium was identified—part of a plot of four twin condominiums—in the north-western suburbs of Rome, XIII–XIV municipality, while for the linear multi-storey building typology an ERP condominium was identified—which is repeated 18 times with different orientations according to *Piano di zona 02v*—in the north-eastern outskirts of Rome, IV municipality. Both buildings were designed in the late 70s and built in the 80s in distressed urban areas of the city that differ in density (150 inhabitants/ha in Torrevecchia and 98 inhabitants/ha in San Basilio), in the degree of marginality compared to the adjacent context and the rest of the city as well as in the plano-volumetric system.

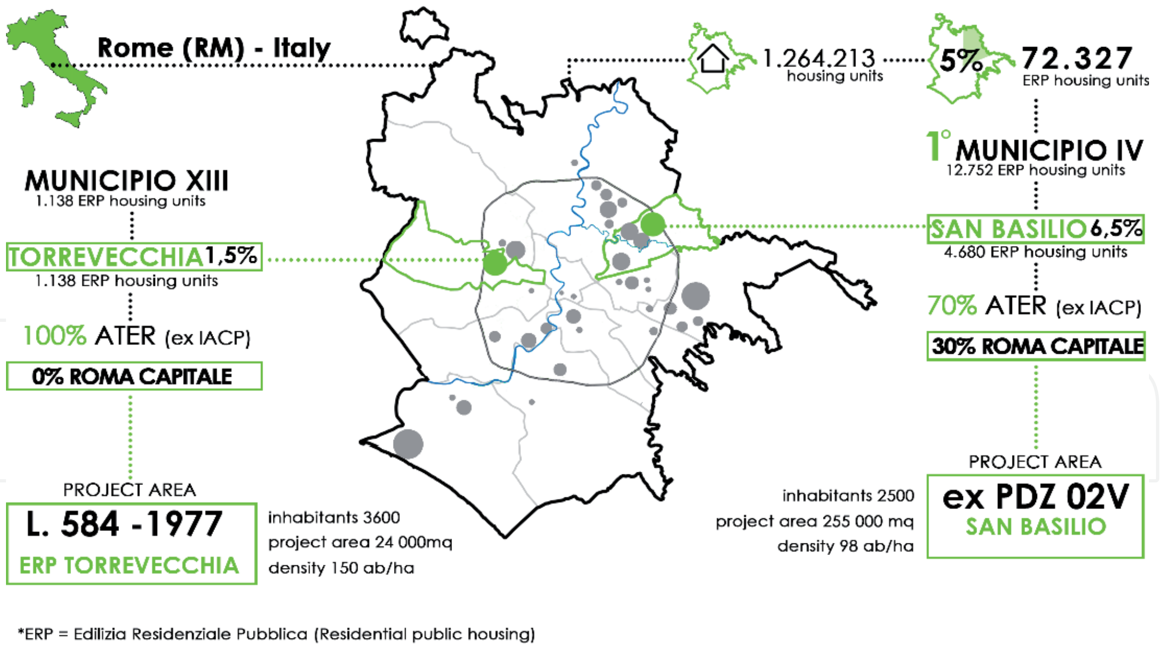

Figure 1.
Territorial framework: two ERP case studies in Rome.

The methodology adopted in this research allows, once the different hypotheses have been identified, to evaluate both the technical (energy savings that would result) and economic feasibility, as well as to verify the overall compliance with national and local regulations.

The methodological approach followed for both case studies provides for an analysis of the context and the current situation of the buildings starting from a territorial and urban framework with a specific focus on mobility, facilities and greenery. Subsequently, demographic, socio-economic and housing demand surveys were carried out. Ultimately, an environmental and micro-climatic analysis both of the entire context and the building under examination was carried out and finally, the architectural and technological components underwent a thorough examination. The aim is to detect critical issues at the building and housing level and to subsequently define the typological and functional program and the overall intervention strategies in line with technological and environmental requirements. The definition of the general morphological-functional characteristics of the intervention about the interaction model between microclimatic factors and the context led to the preliminary design. This initial design stage was developed according to studies and technical validations set at a meta-design level, followed by a functional study and the reinterpretation of housing schemes and supplementary facilities, according to the social demand. At last, a summary report on the identified demand/performance system was drafted: clarification of the environmental technological requirement system and its related design choices. The different strategies and design solutions underwent a definitive design elaboration of the building system and its subsystems and components in line with the environmental context and their interrelations with the transformations induced by the intervention.

5. Tower high rise building typology in Torrevecchia, Rome

The Torrevecchia district (**Figure 2**), built with funding from law L. n. 584 of 1977, is an area of approximately 24 ha with 1074 accommodations for 3600 inhabitants located in the north-west area of Rome in the Primavalle district, XIII–XIV

Figure 2.
Aerial view of Torrevecchia district (source: Google Earth).

municipality. It is owned and managed by the autonomous institute of popular housing (IACP), a specific Italian institution to promote, build and managing public housing to assign to citizens on low income rented at controlled rates. The architects P. Barucci, L. Passarelli and M. Vittorini were in charge of its design and execution. Until the 1960s Torrevecchia was part of the *agro romano,* and during the 1970s the area was affected by strong urbanization. The district is defined to the south by via di Boccea, to the west by via di Casal del Marmo, to the east by via Mattia Battistini and to the north by via Trionfale.

The plano-volumetric scheme is developed around a central square defined by four 15-storey high tower buildings (76 apartments) on which a group of offices and a bar overlook. Long 4/5 storey buildings (192 apartments) branch off from the central square with three levels of housing and a ground floor meant for shops, which were never realized.

Thanks to a progressive series of shifts, these volumes tend to spread out towards the extremity of the area thus creating in-between them two green spaces large enough to host respectively a small public park and a sports field. Car parking spots are located on the external side of the linear storey buildings, thus remaining outside of the central green areas defined by the building volumes.

Overall, the architectural solutions adopted in the different buildings are rather simple and they all respond to the constraints set by the standards imposed by law and by the economic means: prefabricated concrete panels and ribbon windows with metal frames.

5.1 Analysis

The IACP complex is commonly known as the "Bronx" due to its architectural aspect (poor architectural-spatial, environmental and energy quality of the buildings) and the socio-economic conditions of the area. The complex is strongly marked by economic precariousness, by the absence of public spaces and areas for meeting and socializing, by the absence of life and services at ground zero, and eventually by lack of maintenance and building degradation.

According to 2011 ISTAT census data (the Italian National Institute of Statistics, which is the main producer of official statistics in Italy), one out of four residents appear to be unemployed and 9 out of 10 people have reached a level of education below the middle school. The social hardship index, which provides a measure of the possible social-occupational drawbacks, is among the highest in Rome.

An analysis of mobility and facilities (**Figure 3**) reveals a lack of good quality common spaces, a poor and inefficient transport system that makes nearby facilities not accessible. The Battistini metro station (line A), which connects the district

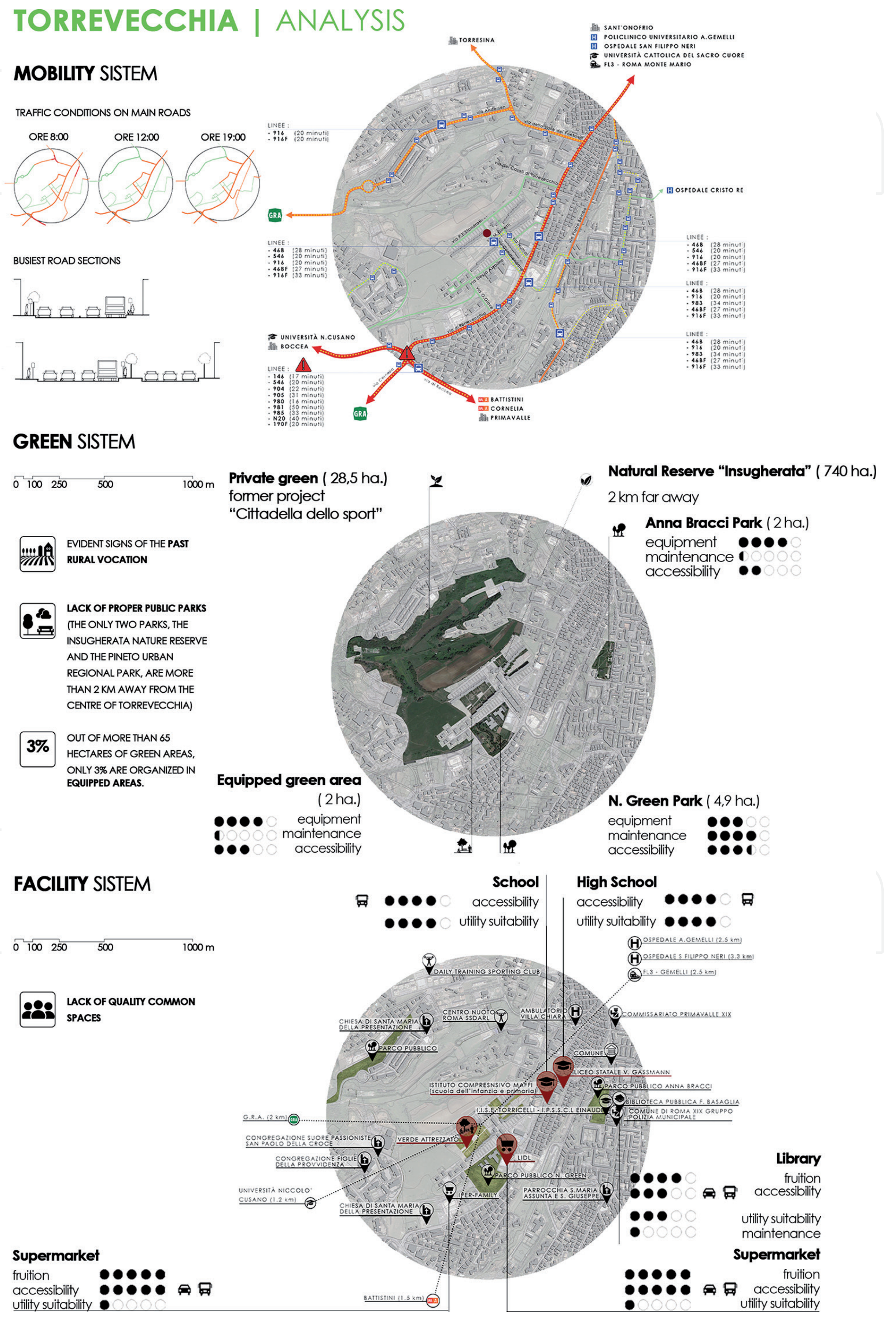

Figure 3.
Torrevecchia district: overall analysis.

with the city centre, is 2 km far from the complex and can be reached in approximately 25 min on foot and in 15 min by public transport. Of the 12 bus lines covering the area, only 4 connect Torrevecchia with the city centre.

Data regarding facilities shows that compulsory schools are insufficient to serve the catchment area. Conversely, there are four technical/professional schools within a 2 km radius of the area under examination. The entire area suffers from a serious lack of facilities which is revealed by the presence of one pharmacy for every 24,500 inhabitants, as opposed to what is required by the Italian law L.362/91 (Art. 1), which is one every 12,500 inhabitants.

Torrevecchia still preserves evident signs of the past rural vocation. The valley between the IACP complex and the Quartaccio district is the least urbanized part of the neighborhood. Despite several green expanses, still not affected by irregular urbanization, the neighborhood is in fact devoid of proper public parks. The only two parks, the Insugherata Nature Reserve and the Pineto Urban Regional Park, are more than 2 km away from the centre of Torrevecchia. Out of more than 65 ha of green areas, only 3% are organized in equipped areas.

Air quality is significantly and positively affected by the abundance of proximity greenery (parks and reserves), although uncultivated and derelict. The average concentration of nitrogen dioxide NO2 is about 32.13 μg/m^3, far lower than the annual limit value for human health protection, established by D.Lgs. 155/2010 which provides for a maximum limit of 40 μg/m^3. As for fine particles, according to what is reported by a PM2.5 map obtained from a dispersion model, the average annual concentration is 18.31 μg/m^3, which is far lower than the limit value of 25 μg/m^3 (D. Lgs. 155/2010 in force since 2015).

As regards the microclimatic conditions (**Figure 4**), in the summer season, the area is affected by winds coming from south west (speed of 16 km/h) which considerably contribute to cooling the south-west area that is most of the time subject to direct radiation during the day, given the poor vegetation and the low building

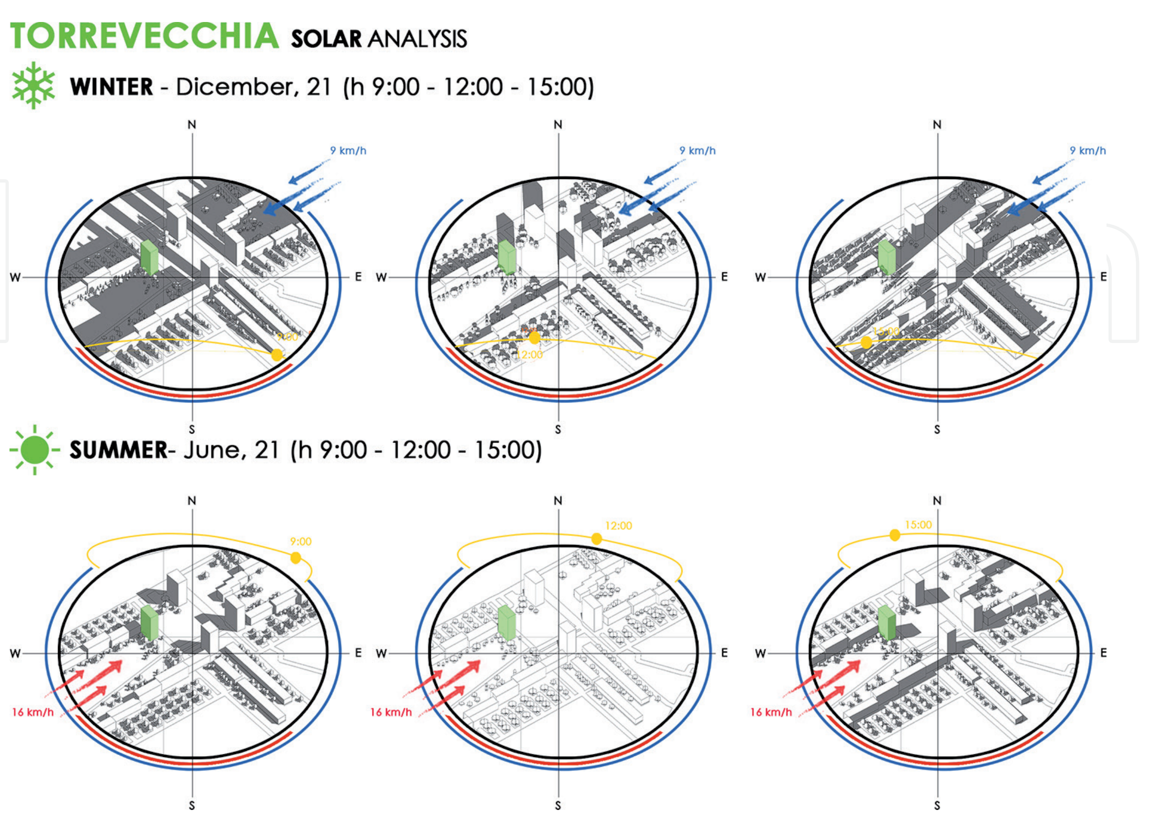

Figure 4.
Solar analysis: the tower building in Torrevecchia district.

heights. The square to the north-east receives just as much radiation, but the layout of the surrounding buildings prevents it from adequate ventilation. In the winter season, the cold wind coming from north east (speed of 9 km/h) sharpens the perception of comfort in the north-east square, which remains cold and in the shade all day long taking into account average winter temperatures of about 7°C. Throughout the day, the south-west square catches the sunlight in its highest part since the shadows cast by the storey buildings are reduced compared to the width of the square.

The tower buildings, especially on the higher floors, enjoy summer ventilation from the south-west but suffer from winter ventilation on the north-east façades, which correspond exactly to the façades with a higher percentage of openings.

The tower buildings, 43.2 m high and with a floor area of approximately 4140 m^2, house 76 accommodations (48 units of 60 m^2 and 28 of 45 m^2) for 248 estimated occupants. A comparison between current users and the availability of floor area, results in 16.7 m^2 per person. According to the national legislation, the building should thus house no more than 207 inhabitants. The 60 m^2 apartments feature a double exposure while the 45 m^2 apartments have a single-exposure. The 60 m^2 apartments are designed to accommodate 4 people but both bedrooms (12.4 m^2 and 12.8 m^2 big) are smaller than 14 m^2, thus do not meet the current minimum standards. It is estimated that the prevalent (50%) family unit typology in Torrevecchia is composed of 1 or 2 members, while families with 4 members account for only 12% of all families.

5.2 Solutions and strategy

Starting from the overall critical evaluation a project concerning both adjacent outdoor and indoor spaces has been developed with particular emphasis on bioclimatic solutions (**Figure 5**). In the first place, it is essential to redesign the building's connection to the ground, its consequent relationship with the street as well as the intermediate in-between public spaces, to provide meeting and relational opportunities. A necessary prerequisite is an involvement of the inhabitants from the very start, ranging from the preliminary design to the future management and care of common spaces. To integrate the facility system, currently rather inadequate, and enhancing the relationship between building and streets, an elevated square is proposed. The new plaza consists of a solid volume with internal excavated patios and courtyards. Vocational training laboratories, also meant to work as local facilities are located on the ground floors of the towers and in the hypogeal areas beneath the elevated square. A system of ramps allows connecting the different levels on which the public outdoor spaces are distributed. Therefore, the square becomes an open space arranged on two levels on which some food services, laboratories and craft shops open. The internal patios enable to host in the hypogeal spaces several other facilities and services, providing them with adequate light and ventilation and with quality green outdoor space of relevance. The derelict south-west green square is transformed into plots of collective urban gardens managed and used by inhabitants.

When it comes to the tower building, the redesign of the ground connection through an excavation on the short façades (north-west and south-west) strongly contributes to improving thermo-hygrometric and visual comfort parameters of the former basement which is thus freed on two sides from direct contact with the damp ground. The ground floor and the basement are merged to obtain double-height rooms suitable for hosting a kindergarten and fab-labs with an external space of relevance gained thanks to the excavation.

To maximize the feasibility of the project, the intention is to limit as much as possible the need for the inhabitants to temporarily leave their homes. Therefore, priority actions address the need to provide all accommodations with adequate living space in terms of square meters to satisfy standards imposed by national law.

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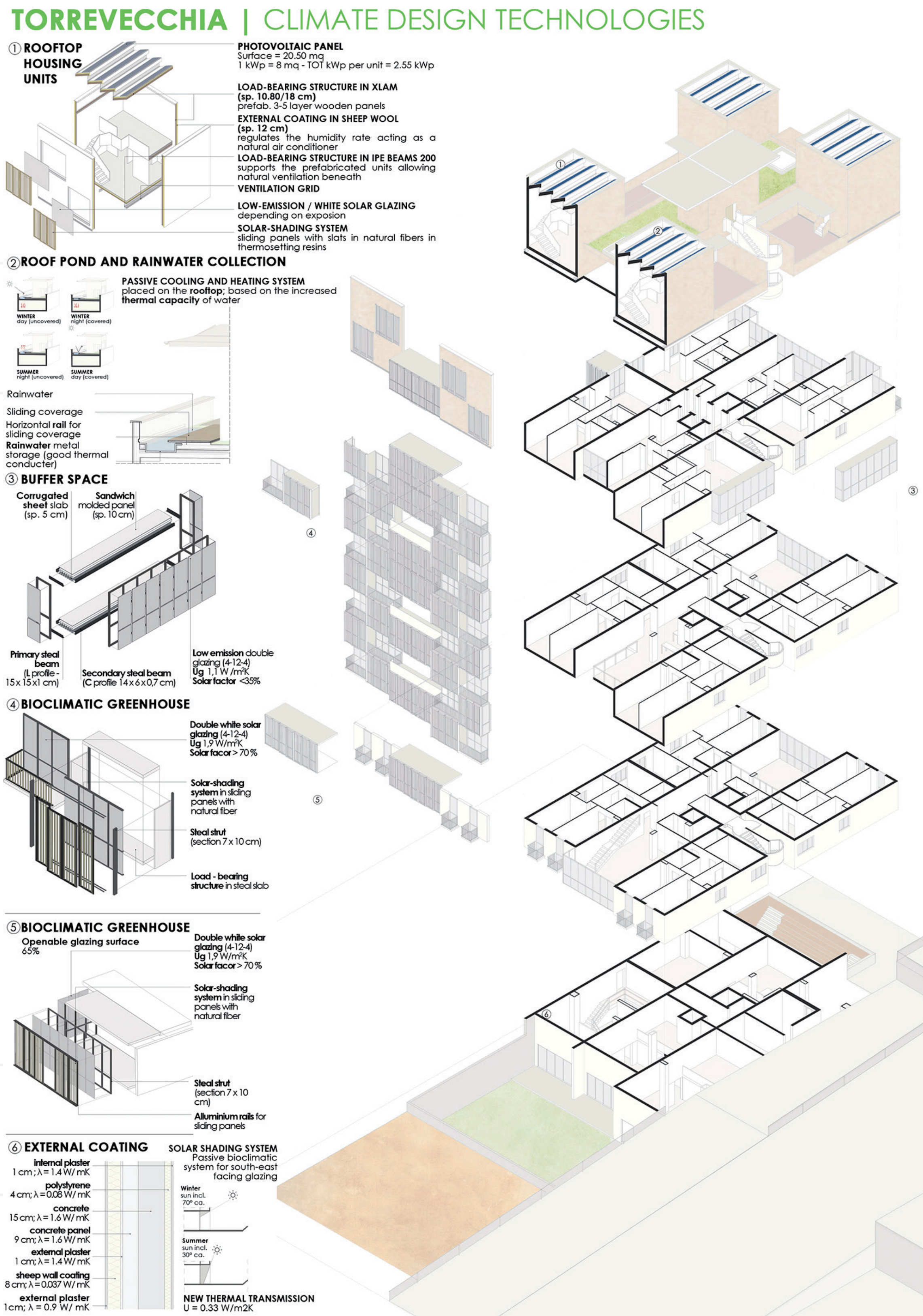

Figure 5.
Exploded axo: overall project and focus on bioclimatic solutions.

The addition of plug-and-play modules on the north-east and south-west façades, diversified on a technical level according to the exposure, can solve simultaneously problems related to poor lighting, poor insulation and consequent thermal comfort and under-sizing. The buffer-space modules added to the north-east façade and the bioclimatic greenhouses added to the south-west façade make up new indoor or outdoor living spaces, diversified internally about the type of environment to which they are added and to the needs of the occupants. It's a system of prefabricated units, ranging from 2 to 8 m^2 big, which add a total of about 10 m^2 to each dwelling, which corresponds to 17% additional surface area in the case of the two-room apartment and 14.5% for the four-room apartment.

The bioclimatic greenhouses leaning on the south-east, south-west and south elevations constitute heat accumulation spaces to introduce preheated air into the apartments. The structure is made up of modular steel elements with transparent vertical closures in white solar glass, with a solar factor higher than 70% and with an openable glass surface of 65% out of the overall transparent closure. Sliding panels with adjustable slats in natural fibers and thermosetting resins work like shields. The modules jut out differently according to the functional and structural needs, ranging from 120 to 240 cm. The buffer-spaces, attached to the north-east elevation, highly contribute to improving the overall energy performance, through the reduction of heat loss and consequent thermal gains in winter and through the dissipation of heat in summer. The overhang is 90 cm and the structure is similar to that of the greenhouses but with low-emissivity glass and a solar factor lower than 35%.

New dwellings can be added on the roof, taking advantage of the incentive offered by the regional law L.R. 7/2017 on urban regeneration which allows adding 20% of the original building volume or the original floor surface in case of energy efficiency interventions on residential buildings. The new volumes have a dry load-bearing structure in X-Lam panels and are placed on a load-bearing structure in IPE steel beams to detach and slightly lift the housing module from the existing roof and thus ensure natural ventilation. Each dwelling is equipped with photovoltaic panels (20.50 m^2) and solar collectors integrated into the roof to assure self-sufficiency in terms of energy.

The original flat roof is replaced with an extensive green roof covered by a pitched canopy which, besides ensuring shading, is also designed to collect rainwater through the central impluvium for irrigating the green roof. The green-blue roof combines different technologies allowing an increase in the storing capacity and a control system of the water flow to release. The green roof helps to cool and humidify the surrounding air, positively affecting the microclimate with slight effects also for the squares located at the street level. In doing so, the storey just beneath the roof slab gains in thermal insulation, therefore less indoor overheating results in less consumption for air conditioning, affecting the overall energy balance. In addition, the vegetated surface effectively protects the waterproofing membrane from UV rays, hail, heat and cold, contributing in the long term to the building envelope maintenance. At the same time, the roof becomes a common space available for all the building users.

Where plug-and-play modules are not applied, an 8 cm sheep wool insulation is laid on the external current envelope to achieve a new transmittance of 0.33 W/m^2 K to ensure an overall optimization of the building energy performance.

6. Linear multi-storey building typology in San Basilio, Rome

San Basilio (**Figure 6**) is located in the IV municipality, in the north east of Rome, in the urban area 5E, and borders the Grande Raccordo Anulare, an orbital motorway that encircles Rome, to the east and Casal de' Pazzi and Tor Cervara to the west. The municipality is delimited by the via Nomentana to the north, by the municipality of Guidonia Montecelio to the east, by via Tiburtina, the Aniene river, the A24 motorway and the Rome-Pescara railway to the south, and the Rome-Florence railway to the west.

Between 1981 and 1988, the *Piano di zona 02v*—San Basilio social housing urban plan—part of the 1981 supplementary variant of the general urban plan, provided for the construction, based on a project by Antonio Salvi, of 18 linear buildings

Figure 6.
Aerial view of San Basilio district (source: Google Earth).

of 6–7 floors over an area of 25.5 ha destined to settle 2500 inhabitants. The intervention is not well integrated with the existing fabric and is characterized by an orthogonal system of roads that shapes and defines the various plots. The buildings too are arranged in an orthogonal way and form green courtyards that open up towards the roads and a series of inter-closed courtyards at the points where the building heads come close to each other. San Basilio hosts 6.5% of the ERP accommodations in Rome and about 36% of those in the IV Municipality, gaining first place in terms of ERP accommodations in the city.

6.1 Analysis

According to the 2011 ISTAT census, it is clear that about 27% of the district inhabitants are between 45 and 60 years old and over half of the families are composed of a single member, 27% of 2 members and only the remaining 20% are families of 3, 4 or 5 components. One-third of the inhabitants have not more than a middle school diploma and only 10% have a university degree, half of the figure for graduates in Rome (20%). The number of unemployed is about 2% higher than the Roman average and about half of the population lives in rented apartments. The neighborhood is also known for the strong presence of petty crime and drug dealing.

Different multi-thematic analyses were carried out concerning mobility, facilities and green systems (**Figure 7**). The mobility analysis highlights how the area under examination is a sort of enclave to the district that stretches to the west, as it is connected to the urban fabric of the old San Basilio district and the rest of the city only by two access roads. The closest metro station is almost 3 km away. A station was supposed to be built in the old San Basilio area but the project for the extension of the metro Line B has never been realized. As for local public transport, although the area is served by several bus lines, these are not sufficient to ensure a direct and rapid connection with the city centre.

With regard to the facilities, since there are no public or private ones within a radius of 250 m from the area under examination, and only a mechanic within a radius of 500 m, one is forced to travel almost 1 km to reach a supermarket, pharmacy or the nearest primary school. 57% of the district facilities are ascribable to retail trade, while public space meant for squares does not exceed 2%.

The several parks and green spaces in the area are unequipped and poorly maintained. In general, the outdoor spaces lack even the most basic elements of street

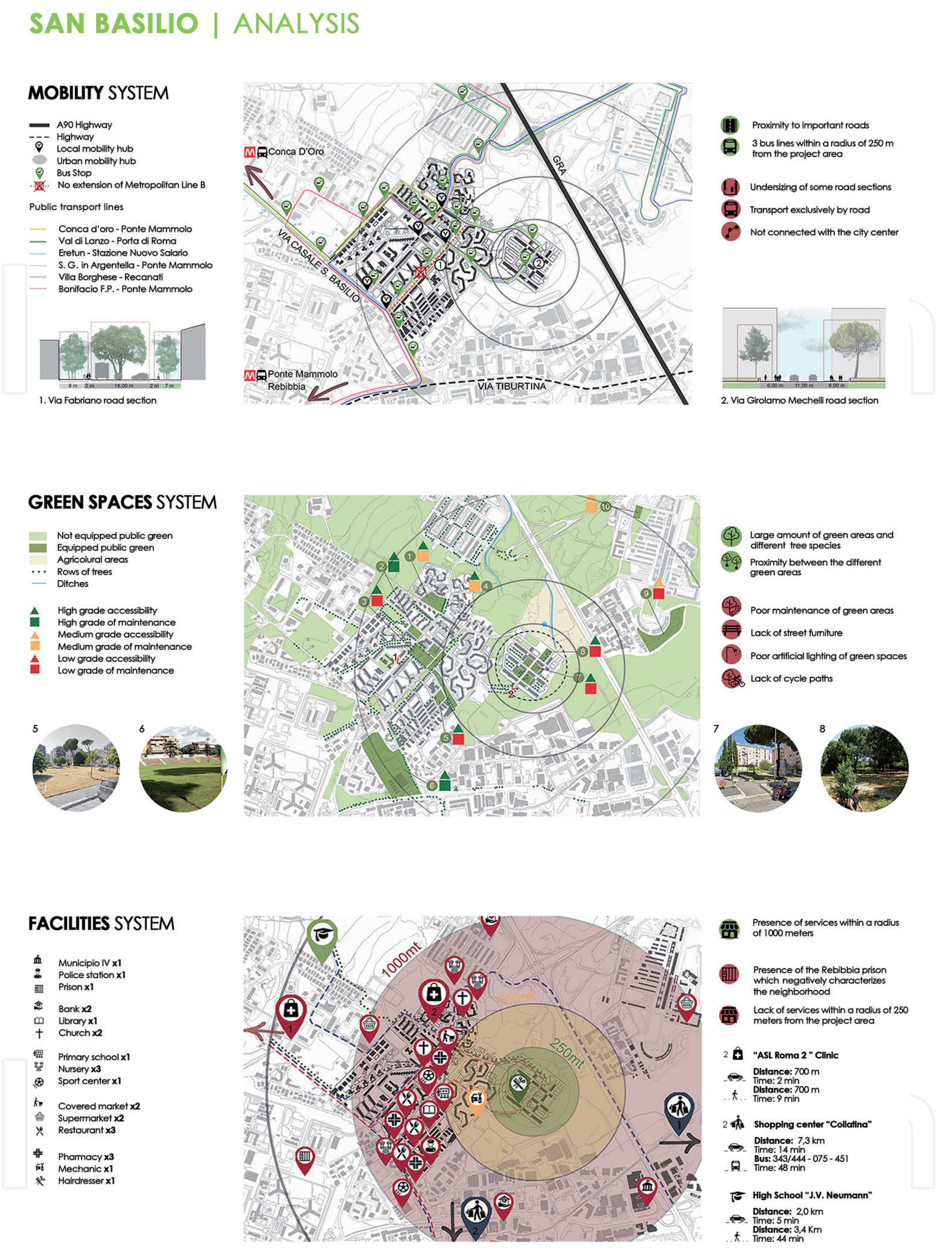

Figure 7.
San Basilio district: overall analysis.

furniture. This leads inhabitants to use these spaces only to go from one place to another and not for social purposes. Moreover, inadequate public lighting increases the feeling of insecurity among the inhabitants.

The microclimatic analysis (**Figure 8**) shows that the area under examination is affected by cold winter winds coming from east, north-east (about 9 km/h) and by hot summer winds coming mainly from south-west with a speed of approximately 16 km/h. In the summer season, both the north-east square and the southern square adjacent to the building suffer significant overheating phenomena throughout the whole day, yet moderated by ventilation. In winter, the northern square lays most

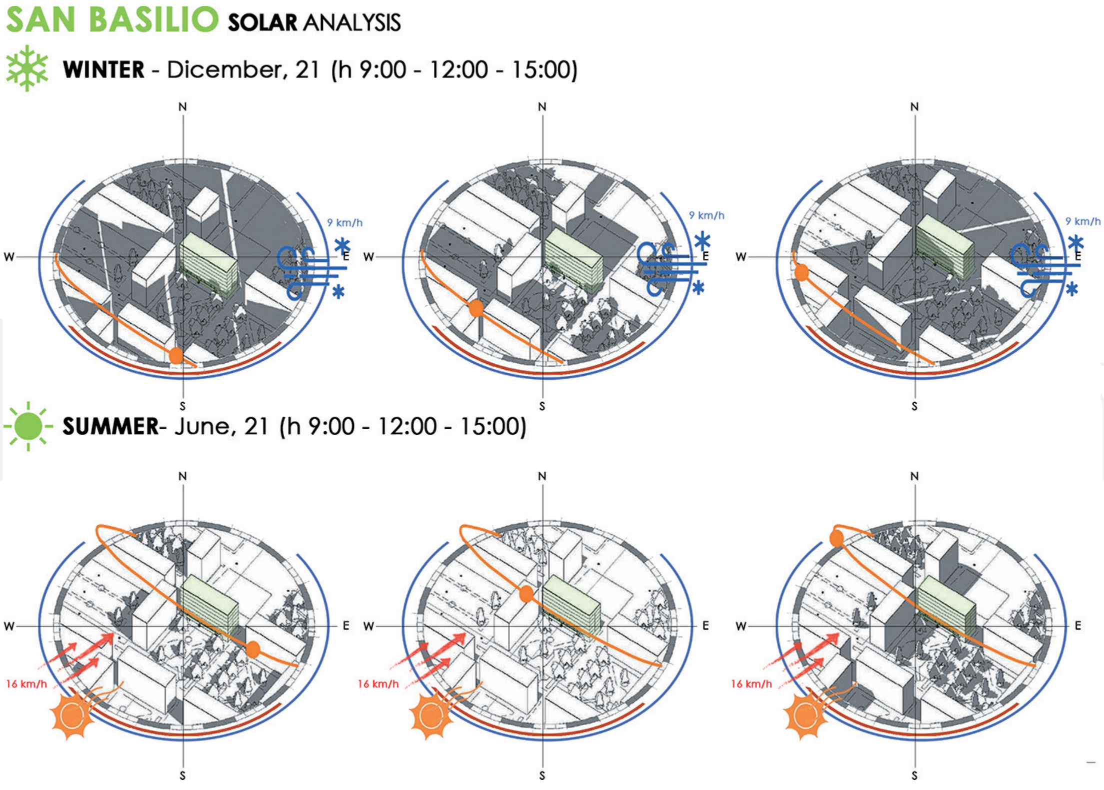

Figure 8.
Solar analysis on the linear building in San Basilio district.

of the time in the shade and is constantly exposed to cold winter winds due to the absence of adjacent buildings.

The building under consideration (6G) is a linear multistorey building typology of about 42 × 13 m consisting of 7 floors above ground and a basement floor. The building currently houses about 135 people for a total of 45 apartments of 50, 60, 80 and 100 m^2, accounting respectively for 40%, 30%, 25% and 5% of the total housing units. The structure is in reinforced concrete bearing walls that define a succession of different sized spans parallel to the short side. The façade is characterized by prefabricated concrete blocks with a minimum insulating layer of glass wool. The joints have not been carefully designed and the discontinuity of the insulating layer causes several thermal bridges. The building is equipped with two staircases and the access is via a gallery located on the ground floor at a height of +1.00 m, above the cellar floor, accessible from the condominium staircases. Currently, the ground floor houses, in the eastern part, two special housing units for people with physical disabilities and two rooms initially designed to be a condominium space and a laundry for common use. At the moment, the western part is occupied by storage spaces but it was meant to be—according to the original project—a *pilotis* floor with a walkway at a height of 0 m from which to access the gallery via the staircase. The upper floors house the apartments and each staircase serve from 3 to 4 units, two-thirds of which have single exposure. The living spaces do not face undersizing problems since all the indoor spaces meet the minimum surface and height standards for public housing and besides, aero-illuminating ratios are verified in all rooms. The staircases lead up to the roof level.

6.2 Solutions and strategy

The analysis of the current condition reveals the need to rethink the building in all its aspects (**Figure 9**) starting from its connection to the ground not only in terms of spaces and functions but also about the square in front. The special apartments

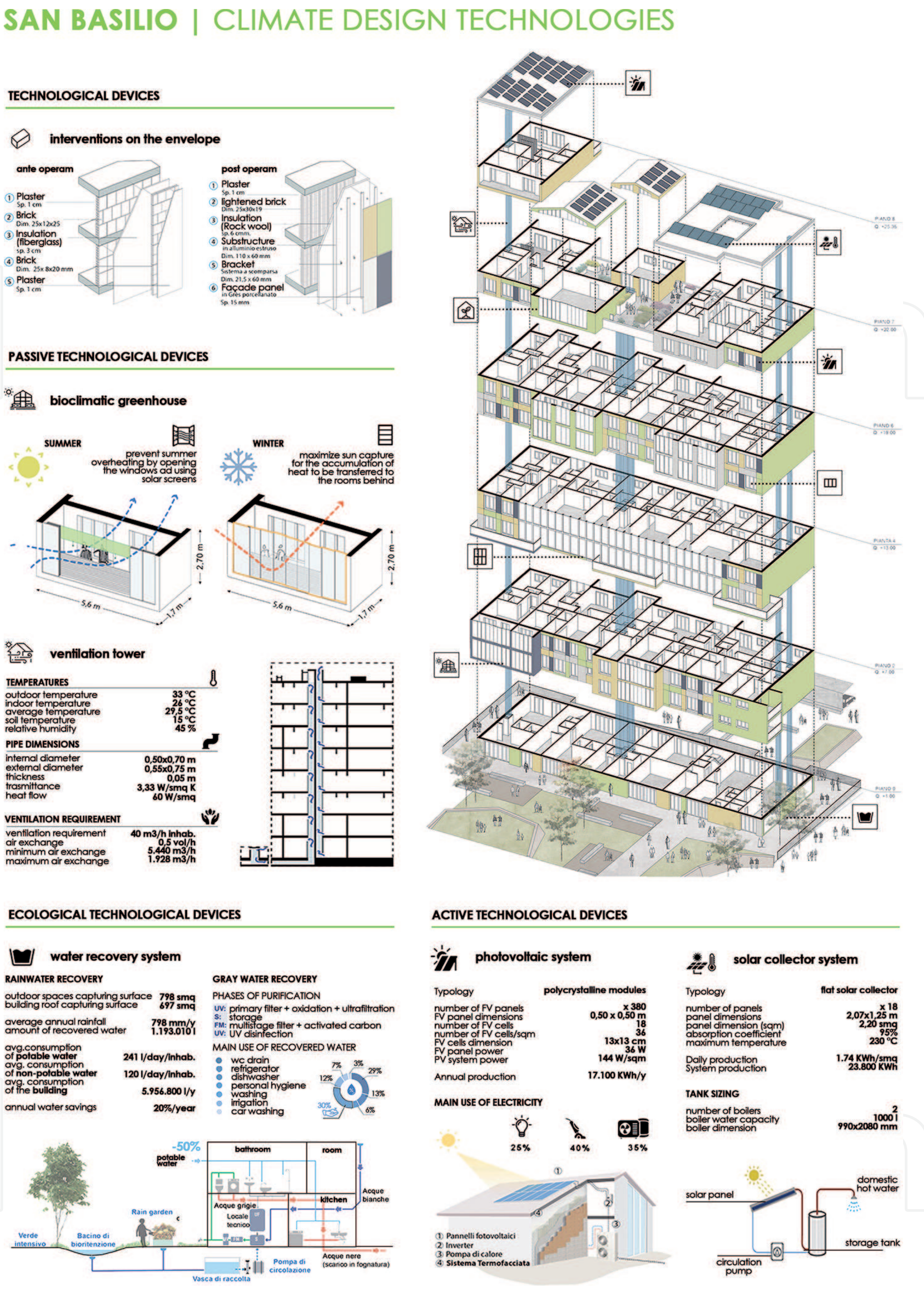

Figure 9.
Exploded axo: overall project and focus on bioclimatic solutions.

on the ground floor are to be relocated, in terms of living space, on the roof level and the currently unused common spaces are to be converted into local and building facilities chosen according to what emerged from the previous social analysis. In rethinking the relationship with the outdoor spaces, the current gallery at a height of +1.00 m is redesigned in terms of accessibility, use and relationship with the square, providing for its expansion in some points to create terraces to serve the new activities and rest areas to encourage meeting and socialization occasions. A co-working, refreshment and internet point could be located in the western part of the ground floor (internal height of 3.70 m) at the same level as the square and near the main road. These spaces are thought of as facilities for the entire local community. The remaining part of the same floor (with an internal height of 2.70 m) could host a series of flexible spaces, including a medical-assistance clinic with an adjoining small outpatient clinic where professionals can offer different services on shifts, multipurpose spaces for courses and activities and a bicycle repair workshop.

Overall, the existing envelope does not meet current national standards for energy performance for buildings. In this regard, a new insulation layer must replace the previous thin and inadequate one together with the application of a ventilated façade in specific parts. Old windows are replaced by new ones in recycled aluminum with thermal break and double glazing with argon gas inside, with a global transmittance of 1.56 W/m^2 K compared to the maximum 1.80 W/m^2 K required by law.

The current design of the housing units of the standard storey does not make the most out of the living space. A new distribution of indoor spaces in favor of living areas located south and an implementation of new spaces to increase liveability, are required. In this regard, steel plug-and-play modules added to the façade, besides providing additional volume, can also be configured as bioclimatic devices by hosting greenhouses or buffer spaces depending on the orientation or, in some cases, as balconies or galleries. To make the housing units more compliant with the family units—according to socio-demographic data—one standard storey could be turned into a cohousing for about 40 members. This housing typology, mainly designed for relatively young users, single or couples, spreads over one entire floor and is accessible from both staircases. The sleeping area is essentially located in the east and west wings and the north. The south front instead hosts several shared spaces in sequence, such as a kitchen equipped with a dining area, a common living room, a mini cinema/games room and a common laundry room, all joined by a single glazed connection placed in adherence to the south façade. To ensure adequate ventilation inside the single-exposure apartments (about 60% of the total), a geothermal cooling/heating system operated by wind towers is inserted. In the light of the microclimatic analysis, the tower collection heads should be placed where airspeed accelerations occur both in summer and in winter. The air is trapped and then directed through underground ducts—where thanks to geothermal energy it is pre-heated/cooled depending on the season—to the apartments to be, in a second step, introduced into each room through a distribution system installed in the false ceilings positioned over the service and distribution spaces.

With regards to the roof, the availability of such a large free surface allows the implementation of different passive and active strategies as well as technological devices. Special housing units (once located on the ground floor) and common spaces are relocated on the roof. These new accommodations, larger and suitable for families of 4–5 members, have been designed for a different target audience, to encourage different people to approach the neighborhood and thus promote social *mixitè*.

Moreover, a common laundry room, a greenhouse for food production and a common outdoor kitchen/dining area are integrated as new volumes on the roof. The roof is also equipped with a system for the collection and reuse of rainwater and gray water. The uncovered surfaces are redesigned to better capture rainwater and convey it to specific collection points. From here, the water is filtered and purified and then used for cleaning and irrigation purposes for outdoor spaces, toilet drains and washing machines. With regard to gray water—before being stored in the collection point—it undergoes a different purification process and is later reinserted into the general circuit. This system can bring about significant clear water savings accounting for about 20%. The building is also equipped with a photovoltaic system for electricity production. The system is composed of polycrystalline modules of the size of 50 × 50 cm with a nominal power of 35-W peak each. The energy produced, equal to about 17,000 kWh per year, will feed, not only the lighting system—replaced with LED elements—but also the heat pumps for the underfloor heating system and part of the domestic consumption. A small portion of the roof is also meant for a solar thermal system for domestic hot water production, consisting of 18 panels of about 2 m^2, for a total of 36 m^2, able to cover 50% of the annual housing needs.

7. Results and conclusions

Currently, most of the interventions on ERP have an emergency nature: direct operations aimed at solving specific problems in the short term. This logic, devoid of investment, does not allow to respond to broader issues, without halting the heritage deterioration. Today it is even more necessary to outline intervention strategies capable of coping with the technical-functional aging of buildings. The ERP heritage of the city of Rome can become the key element for a qualitative regeneration of the city. According to socio-demographic data, it is possible to point out similar contexts, characterized by strong social unrest, petty crime and a high unemployment rate (23% in Torrevecchia and 16% in San Basilio). About the district population, that of San Basilio is generally younger and made up of larger families compared to that of Torrevecchia. Yet, in both cases, the most recurrent family unit is composed of 1 or 2 members. Not only the different characteristics of the plano-volumetric system but also those related to the socio-economic, environmental and microclimatic context play their part in the choice of which strategies and solutions implemented.

The study carried out allowed to investigate and compare the limits and the potentialities deriving from the building typology and its plano-volumetric system:

- Ground floor. As a direct consequence of the building typology, the linear multistorey building undoubtedly presents a greater availability of space in terms of surface area. This feature allows the introduction of several different facilities on the ground floor, by simply replacing the existing housing units, poorly lit and ventilated and with serious privacy concerns. The new facilities are chosen according to the socio-demographic analysis output and the structural-dimensional characters of the building and address different target users at different scales (inhabitants of the building, of the neighborhood, of the district). In addition, the larger perimeter of the ground floor in this building typology allows greater freedom in rethinking the relationship with the relevant outdoor spaces, enhancing the integration between facilities and pertinent outdoor spaces. In the tower building typology, given the limited availability of surface, the possibility of integrating different facilities is consequently quite limited. The reduced ground floor surface area requires to use of additional storeys to host facilities running into the limits resulting from the reduced internal heights of the upper floors (originally intended for housing). About the useful heights, in the specific case of San Basilio, two public exercises with a district-scale catchment area can be introduced in the area with a useful height of 3.70 m. In the case of Torrevecchia, to overcome these design limitations, the creation of a new elevated public square, in-between the tower buildings, revealed to be the best solution for hosting laboratories for professional training, retail shops and craft labs whilst guaranteeing quality outdoor space at the same time.

- Standard floor. The linear multistorey building, as opposed to the tower typology, tends to house a greater number of single-exposure apartments, which consequently face serious problems related to indoor ventilation. This aspect is mainly linked to the need for a greater surface area for connection purposes to serve all the apartments. Unlike linear typologies, in tower buildings, the connective surface is reduced to the least and corresponds to the stair and elevator block. On the other hand, the linear typology allows greater freedom in redefining the standard floor plan by changing the dimensions of the existing housing units to adapt them to the user's needs. About the apartments, in Torrevecchia their dimensions were deemed suitable for the users and more than two-thirds of them have double exposure. In the case of San Basilio, this proportion is roughly the opposite, with % single exposure apartments accounting for 60%. As mentioned above the single exposure led to the introduction of wind towers to improve ventilation in indoor environments. Some of the apartment rooms in Torrevecchia, such as the double bedrooms, do not meet the minimum standards required by law. Therefore, the addition of new plug-and-play modules on the façades allows for to increase in the limited current surface area and meets the standards.

- Roofing. Taking into consideration the linear typology, likewise the ground floor, the roof level has a greater surface. It offers, in the first place, the chance to implement several technological, active and ecological devices, to gain significant overall energy-water savings:

    - A photovoltaic system for electricity production: the larger roof surface allows to install a more powerful photovoltaic systems capable of satisfying a higher share of electricity consumption. In the linear typology, the cost is maximized, since it does not require any integrated systems on the façade, and since the system is more efficient thanks to the possibility of positioning the panels according to the best exposure.

    - Rainwater collection system: the larger collecting surface allows to accumulate a greater quantity of water, achieving far higher water-saving percentages.

Furthermore, greater space availability also results in the possibility of adding new accommodations and several common spaces such as a laundry room, multipurpose rooms and a common kitchen in order to provide the inhabitants new spaces in which to spend time and do activities together.

Although, the building typology is quite significant in defining the different possible intervention strategies, these must necessarily be contextualized according to the specific study/project area and its *genius loci*, in other words, the socio-cultural, architectural, economical habits and characters of the place.

Conflict of interest

The authors declare no conflict of interest.

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