Housing is a right

Sustainable strategies to preserve tangible and intangible values in social housing rehabilitation

Massimiliano Condotta, Chiara Scanagatta*, and Elisa Zatta

Department of Architecture and Arts, Università Iuav di Venezia.
**Email: cscanagatta@iuav.it*

Abstract: The European social housing stock, built since the early post-war period, now needs major energy, structural and functional upgrading. The owners, almost always public bodies, are therefore called upon to adapt these buildings to the new regulations issued by the European Community. To reduce the costs of intervention, the preferred solution is often that of a complete demolition and a subsequent reconstruction by using newly supplied materials, without considering the non-sustainability and social fallout of this choice. The contribution, starting from the hypothesis that more sustainable building rehabilitation interventions are possible, analyses which social and material supply aspects must be considered, and which design strategies can be applied to achieve the objective. First, the characteristics of social buildings in their historical evolution are summarized to understand their value in a broader non-economic sense. Subsequently, the requirements for a sustainable renovation of the existing social dwellings are analysed, and three design strategies are proposed. A case study is then presented and the application of the three strategies, developed through three Master thesis works, is described. In conclusion, the results of the application of the strategies to the case study is analysed to assess whether it is possible to intervene on existing social housing complexes to achieve better results with a wider sustainability-oriented perspective.

Keywords: design for adaptability principles, nature-based solutions, social housing rehabilitation, sustainable buildings, sustainable strategies, urban mining processes.

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1. Introduction

After both the First and Second World War, the European context saw a spread of social housing which, through different formats, responded to different housing needs. In the 1920s several countries begun to build social rental housing to help the population face the economic crisis, and to address political and social problems. Those buildings, unlike what is common thinking today, were targeting the upper-middle working class, and a limitation in time of the rent subsidies was planned (Breglia, 2012).

In the late 1940s, due to the extensive destruction of cities and the high number of citizens without an accommodation, a large-scale reconstruction begun in most European countries. It is therefore since this acute shortage of residential real estate that it is possible to speak about social housing. As the 1920s social dwellings, this new type of affordable homes – now meant for low-income families – was possible due to public subsidies used to reduce both construction and operation costs, as well as rents (Caves, 2004).

Over time, the idea and aims of social housing changed, and it is possible to identify four different phases (Breglia, 2012) until today: a first phase until 1960; a second one from 1960 to 1975; a third phase from 1975 to 1990; and a fourth from 1990 on. The first phase is linked to, and it is known as, the 'recovery phase', since the aim was of repairing the damage caused by the war and addressing the large housing shortage. Residential properties were built by counting on significant subsidies and funding from the states; these dwellings were then rented below market values, and no attention was given to property management. The second phase is referred to as the 'growth phase', and it was characterised by an increased focus on building quality and urban renewal. Due to the economic growth that started in the early 1970s, which increased the number of property owners, the demand for social housing declined, a context also influenced by the poor quality of the accommodations, in terms of materials, comfort, and the almost inexistent property management. The third phase is commonly known as the 'new housing phase': during this phase, and given the ongoing economic growth, public subsidies were usually reduced since social housing became targeted to small minority groups. In the last three decades, new social housing socio-economics trends raised, distinguishing the fourth phase: families with greater spending power have been turning to higher housing standards, causing a change in the demographic and social composition of the population that benefits from social housing.

Parallel to the second phase of social housing, the alternative idea of collective housing, or cohousing, raised in the late 1960s in Denmark (Caves, 2004). Many cohousing projects were completed in the 1970s and 1980s in Denmark, Sweden, and Germany; as they reduced in European countries in the 1990s, they grew in Canada and USA (Vestbro, 2000). There are slight differences between different collective housing definitions within Northern Europe, but their organisation was always similar: intentional communities of private complete homes clustered around shared space for common activities e.g., laundry room, and common garden. This presence of a shared space is also the main difference with social housing, which are based on private spaces for low-income families.

European Mediterranean countries were less prone to such cohousing experiences but present plenty of social housing buildings that, nowadays, would require substantial rehabilitation and renovation works, both for their age and lack of maintenance over the decades. The Italian territory shows many examples of post Second World War social dwellings owned by public institutions, nevertheless, the official definition of 'social housing'[1] was only recently acknowledged by law (DM 22 aprile 2008): a time interval revealing the poor management these assets have been exposed to for decades.

These kinds of dwellings were built mainly between the late 1940s and the 1970s, and no longer meet contemporary requirements nor laws: the budlings are often inefficient (i) energetically, (ii) functionally, and (iii) structurally. Considering the first point, they were built before the first Italian energy efficiency laws; moreover, their plants (i.e., electric, plumbing, and HVAC systems) are usually old, cause air pollution and do not guarantee indoor comfort. Functionality of indoor spaces does not respond to current requirements as well: the internal layout of each dwelling is not in line with nowadays needs. This is linked both to the changes in users and society, since people spend less time at home, there are fewer housewives (Randstad, 2021), and family units now usually present different sizes and compositions. The widespread structural inefficiency of this building stock was revealed by an analysis conducted after the earthquakes involving the Italian territory in the past 15 years (e.g., OPCM 3274/2003; nota Regione Emilia-Romagna 291982/2012), which highlighted that most of Italy's buildings and infrastructure do not comply with current earthquake-resistance regulations (NTC2018). The first two aspects, energy and functional defects, are the ones that inhabitants perceive the most, and in many cases can be solved without invasive structural interventions; the third one requires expensive and invasive interventions.

It follows on that renovation interventions can lack cost-effectiveness, and a complete demolition reducing existing buildings to debris, followed by reconstruction with newly supplied materials, then appears the most suitable solution considering economic factors. In Italy, and all-around Europe, destructive interventions often resulted in protests by both relocated residents and other community members who see a complete change in their community spaces (e.g., La Villeneuve in Grenoble, France[2]; various social housings in London, UK[3]; Christiania in Copenhagen, Denmark[4]; via Anelli in Padua, Italy[5]).

Based on the assumption that the 'no action' option is not a viable way, since the disuse and lack of maintenance results in safety issues, economic losses, creation of non-places within a neighbourhood and social problems, the 'demolition and rebuilding' solution may also not be the best choice. Indeed, if on the one hand this latter produces new dwellings more suited in energetic, functional, and structural terms, on the other hand it does not fully consider the role that preservation could play in improving the local community quality of life from a comprehensive sustainability point of view, as the Davos[6] and Leeuwarden[7] Declarations suggest.

In fact, in this perspective, the cost-effectiveness of the buildings' demolition and reconstruction is limited to the construction boundary, and has primarily an economic focus, without any reflection on other sustainable factors, both *tangible* and *intangible*; they are:

(i) The loss of material resources, due to missed recycling opportunity because, per 'traditional' approach, the management of demolition rubbles entails downcycling (Reike et al., 2018) or, worse, landfill (*tangible*).

(ii) The loss of material culture, since social dwellings, albeit not valuable architectures, often represent a distinctive feature in urban fabric for a community, and their constructive elements embody the *téchne* of the past (Ghyoot et al., 2018) (*tangible/intangible*).

(iii) The loss of a social message, because the historical memory of both urban and social development of the area is removed together with the dismantling of buildings, and life in the neighbourhood needs to readjust (Crawford et al., 2014; Egan et al., 2013) (*intangible*).

Given the need to avoid losing these three aspects, the convenience of a destructive demolition followed by new construction, over means of preservation through transformation, should be carefully examined, and potential alternatives outlined.

Starting from the depicted context, the aim of the research here presented was to explore sustainable strategies to manage social dwelling complexes, currently lacking functional, energy and structural efficiency, while focusing on avoiding the loss of material resources, material culture, and social message those buildings embody. The adopted sustainability perspective defines a boundary of the system that is broader than the one conventionally assumed – which considers social housing as something to be interpreted in cost-effectiveness terms – and it expands the perimeter to include all the nuances of the community and cultural dimensions instead. The study investigated some of the possible strategies that could be adopted when dealing with the Italian social housing buildings built between 1940s and 1960s. The building stock pertaining to such timeframe is, in fact, the one which needs most rehabilitation interventions today, and represents the 60% of the Italian residential dwellings (ISTAT, 2022). Moreover, the buildings belonging to this period, precisely because of their history and the reasons for their construction, convey more than others the intangible sustainability factors.

The contribution is structured as follows: the first part introduces the research method, the selected strategies, and presents the case study; the second part discusses the results of the implementation of the strategies; the last part draws the conclusions depicting possible future research lines and improvements.

2. Materials and methods

For reaching the aim above mentioned, a case study research method was chosen: a small social housing complex was identified and three different strategies, aiming to preserve material resources, material culture and social message were implemented through three different design projects. The strategies focused respectively on the application of Urban Mining (UM) processes, Nature-Based Solutions (NBS), and Design for Adaptability (DfA) principles. These projects were carried out within the context of three master thesis; each one developed and detailed a different strategy involving a possible management of the buildings with the aim to preserve – with different degrees – their trace in the urban context.

It was decided to apply the design strategies to a social housing complex belonging to the 'recovery phase' built to address the housing shortage of the late 1940s. Even if the architectural value of this type of artifacts is often not recognised, they have an intrinsic semantic value, and are nevertheless bearers of a deeper signification due to the role they have played in addressing a social emergency.

Moreover, these architectures, because of their emergency nature and since they had to be built quickly and, at the same time, efficiently, were conceived, designed, and built based on the most consolidated and rooted technical knowledge in the construction culture of the time. This factor, besides acting as an additional cultural value, led to the construction of buildings which, with their solid brick structures, resist the passage of time better than the ones built with low-quality concrete in subsequent decades. After fifty years from their construction, it is nowadays evident how concrete structures from the 1960s and 1970s, once believed to be eternal, shows durability problems due to deterioration/distress of the structure on the long term (De Risi et al., 2022).

The illustrated projects are three possible strategies among many; the design outcomes are not meant as solutions to the problem or as 'The' alternatives to demolition and new construction, they rather are a way to depict how sustainable places can be obtained by exploring alternative, and less economy-driven, approaches in managing the social housing of the past.

2.1 Description of the three selected strategies

The selected strategies are illustrated in their general approach to define their boundaries; each presents both strengths and possible limitations, which need to be tackled based on the specific implementation area.

The Urban Mining process, first of the considered strategies, is based on the reuse of building components or construction materials salvaged from existing buildings, considered as a 'mine' (Ruby and Ruby, 2010). Indeed, there is no univocal definition for the principle of Urban Mining, which is commonly defined as the recovery of materials from anthropogenic resources (Cossu and Williams, 2015; Johansson et al., 2013) and, as Stollmann (2014) states, it can be understood 'as a strategy of re-evaluating buildings in relation to the livelihood of the urban [space]'. Since buildings and infrastructure are the largest anthropogenic stock and the most prominent product of the urban environment (Aldebei and Dombi, 2021; Koutamanis et al., 2018), the possible reuse of the material resources they 'store' should be carefully considered, especially in light of the more circular patterns currently promoted (European Commission, 2015a; 2020). Within this strategy, existing buildings, which are unfit for further use, can undergo a selective demolition and/or deconstruction process allowing a potential reuse of their materials and elements in another building site. A reduction of the environmental impacts is thus achieved, since the mining of new materials, together with the energy consumption and pollution caused also by the processing and transportation of materials, are reduced (Sabu, 2022). This strategy was chosen because it enables the creation of a new, more functional, morphology thanks to the complete reconstruction; at the same time, the reuse or recycling of the existing built resources allows reducing the material loss. Adopting this approach also entails preserving the material culture, since the original constructive elements can be reused, while the loss of social message is contained because residents can still find elements recalling the previous urban texture. It is therefore a strategy that differs from the conventional linear process of demolition followed by new constructions, since it rather represents an action of 'disassembling' and 'recomposing', within both a material and cultural perspective.

The second strategy is founded on the idea of using Nature-Based Solutions to create more sustainable constructions. The European Commission (2015b: 24) defines them as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions'. Hence, Nature-Based strategies are the ones using NBS, which take their cue from natural elements to reach a certain constructive goal (Mussinelli et al., 2018). Since NBS are inherently transdisciplinary – with their social, political, ecological, and technical dimensions – different actions can be implemented at the same time to produce more environmentally friendly cities (Frantzeskaki et al., 2019; Wild et al., 2020). Some of them are more commonly applied to solve urban issues, such as the use of renewable materials over plastic ones, conversion to green roofs, implementation of open green spaces, urban trees' planting (ICLEI, 2017). Their implementation in urban contexts is more and more frequent, despite the evidence on their sustainable effects besides the environmental ones remains scarce, due to the complexity of assessing impacts such as the ones of social cohesion (Frantzeskaki et al., 2019). A Nature-Based strategy can be used in new construction or to rehabilitate existing buildings: in this case it is possible to preserve all material resources, material culture and social message aspects while improving the ecological sustainability of the housing. This strategy, through consolidation of structures and architectural elements by using renewable materials, allows the preservation and improvement of material culture and social message, while reducing the input of new materials to natural ones.

Figure 1 | Aerial view of the Garden City of Marghera. The social housing complex is highlighted in colour.

Lastly, the Design for Adaptability was tested as third strategy. DfA is based on the principle that it is possible to avoid a building's obsolescence while minimizing the associated environmental and cost impacts of resource consumption and material waste (Graham, 2005). By planning solutions that allow to modify the space layout in time through limited interventions it is possible to lengthen a building's lifespan, also envisaging uses beyond the ones originally intended. Multiple advantages derive from this strategy, including environmental benefits and the preservation of the building's community and economic value (Melton, 2020). Concerning the environmental factor, the chance of modifying spaces according to the needs allows the reduction of demolitions and use of new materials, while also cutting energy consumption and transportation impacts. The community value lays in the opportunity to preserve the urban community spaces, defined by the open public areas within the buildings, while these latter are being renovated. Moreover, since the adaptation of a building takes less time and causes less disruption than a demolition with subsequent new construction, the benefits for the community cross the reduction in costs and the higher economic value of the neighbourhood once the area is renewed. Although DfA is an approach conceived for new constructions, by adding new volumes to existing buildings it could be possible to maximise the flexibility of both spaces and technological systems, while preserving material resources, material culture and social message. This challenging strategy was therefore chosen to provide a flexible use to the indoor existing spaces through the addition of new buildings improving the distribution layout and including all the updated technological elements.

Common point of all strategies is the need to 'rethink' private and community spaces, and their linked services, which need to be suited to nowadays needs. Further analysis on the possible common aspects of the three strategies can be found in the following sub-section '2.3 Boundaries of the design projects.

2.2 The case study: a social dwelling in Marghera, Italy

The identified case study is located in Italy, in the centre of the Garden City of Marghera, a district belonging to the metropolitan area of the City of Venice (Fig. 1). The original masterplan, drawn up by Emilio Emmer in 1920, imagined a new suburb of Venice on the mainland. As an Italian version of Ebenezer Howard's urban planning theories on the garden city, it was realised immediately after the two garden cities of Letchworh and Welwyn, with which it shares the scheme of the central avenue, fulcrum of the urban composition, the subdivision into lots, and the garden house typology.

The studied social housing complex consists of six buildings, each accommodating eight units on three levels (Fig. 2). The buildings were constructed between 1948 and 1949 by the Engineer Corps to cope with the post-war housing emergency (Fig. 3). Precisely because of the exceptional nature of the intervention, the buildings were constructed on State-owned land, occupying the end of the large central axis that, according to the masterplan, was destined to be a central green artery instead. By the end of the 1940s, therefore, the great urban axis was bordered to the north by the district's main church and to the south by the six social housing buildings (Fig. 4).

From a technological point of view, the buildings are constructed with a solid brick masonry structure, rib and block suspended floors, roofing with prestressed concrete joists and roof clay tiles. This is a well-established construction system that does not, however, meet the structural requirements of current regulations. Regarding the heating system, originally a wood or coal

Figure 2 | Piazza Mercato social housing complex today.

Figure 3 | The social housing complex in the early 1950s.

Figure 4 | View of the area (1957).

stove was installed in each unit. Although this system was later updated with gas boilers and radiators, no insulation layers were added in the envelope; therefore, the buildings currently have very poor energy performances.

The local administration planned to demolish the buildings – at present time still standing – as soon as the last residents are relocated. Such a decision is deemed necessary by the public ownership because the buildings are no longer functional in terms of interior space and energy performance. Despite these technical evaluations, the local community has raised strong protests[8] because the demolition would change the urban appearance and delete the historical memory of the area.

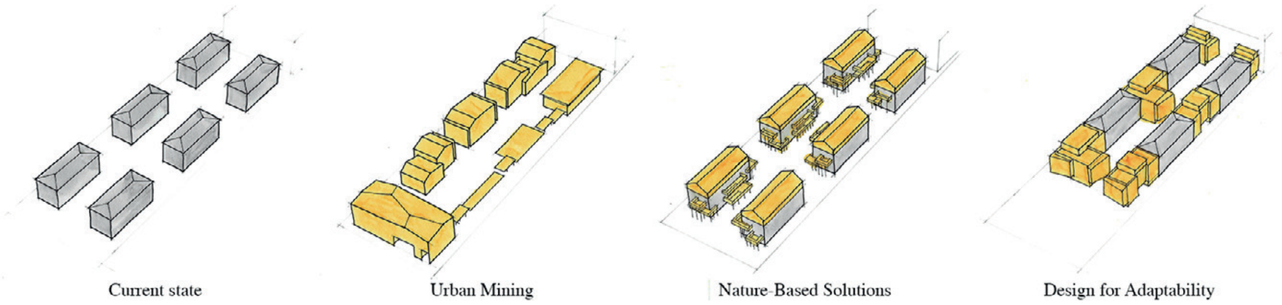

Figure 5 | Volumes and morphologies resulting by the application of the three strategies: UM, NBS, DfA.

2.3 Boundaries of the design projects

As mentioned, and due to the complexity of the topic, the rationale for choosing the three specified strategies derived from an explorative approach focused on the outcomes' sustainable potential, without relying on binding parameters. Nevertheless, the design projects that tested these strategies were supposed to share important common requirements:

The adoption of a life cycle perspective, meant as consciousness of the material footprint of the intervention, being it related to the circular management of materials, the natural materials supply, or the efficient use of the building throughout both the operational life and end-of-life management.

- The objective to preserve, in whole, in part or – literally, *in parts*, the material resources the existing social housing complex is made of.
- The aim to preserve the urban appearance and features of the area, also by increasing the public space and encouraging its pedestrian use, without drastically change the former layout.

To encourage a sustainable life in the neighbourhood, and improve the economic feasibility of each project, a common functional choice was adopted: the introduction of community and public functions on the ground floor of the residential buildings, as well as commercial activities. In all cases this led to an increase in the overall constructions volume, especially to achieve functional improvements in the existing buildings and to include the new functions; however, current urban indices were considered. Each of the three projects adopts a different degree of maintenance of the existing buildings and consequently provides for different layout of new construction as schematically illustrated by Fig. 5.

3. Results and discussion

3.1 Urban Mining process results

Although apparently moved by an exclusively environmental concern, the strategy applying the Urban Mining process aims to preserve more than just the material resources available onsite. The design approach does not fully oppose the actual administration willingness to demolish the existing buildings for subsequent new construction but proposes a more sustainable approach in ecologic, cultural, and social terms instead. This is achieved through several steps:

- Envisaging the deconstruction of the buildings, instead of their demolition.
- Collecting an inventory of the building materials and elements, detailing each entry in terms of weight on the total, dimensions, and residual performance.
- Designing the potential circular patterns of the material flows, maximising the reuse of reclaimed elements over the recycling of materials, and onsite recycling for subsequent reuse in new constructions over offsite recycling.
- Designing the new constructions taking advantage of the onsite available materials and elements, while minimising the new inputs of resources.
- Using the recovered components, materials, and parts of the old buildings to form and shape the new buildings' skin.
- Where possible, install the reclaimed components according to Design for Disassembly (DfD) principles, allowing more cycles of reuse.

As figure 6 illustrates, the project provides: new dwellings with commercial activities on the ground floor on the west side of the area; a multipurpose

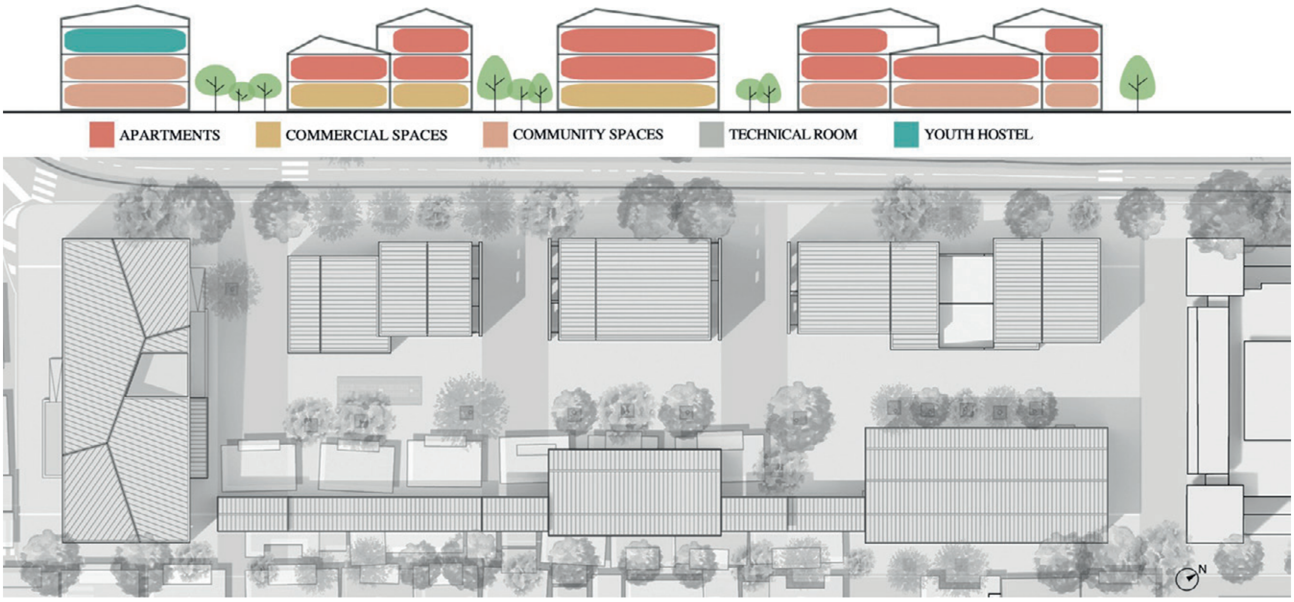

Figure 6 |– Functional section displaying the uses of the different spaces and urban layout (UM).

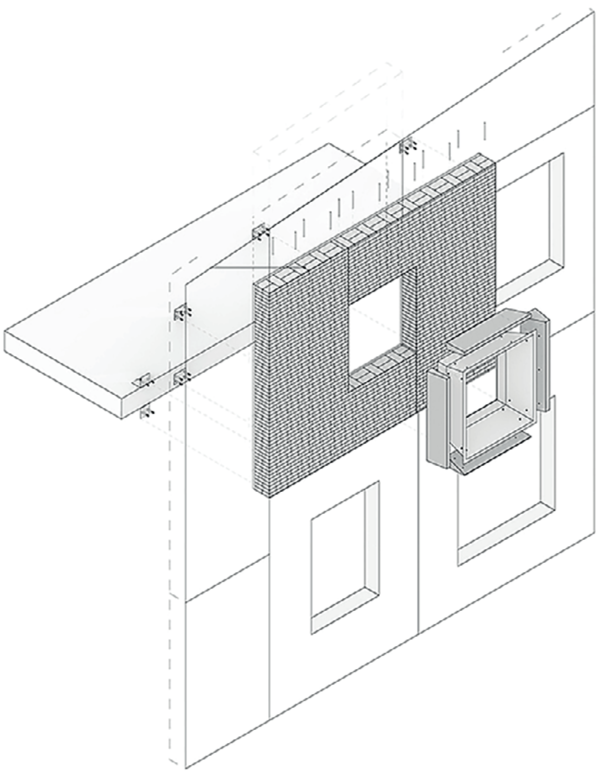

Figure 7 | Reuse of existing external walls 'in parts' to create new façades.

building in the southern part (cultural activities, spaces for associations, students and researchers' residences); a toy library in the north-east portion. The application of this strategy results in a large number of recycled materials and reclaimed elements (respectively 73% and 13% on total weight), most of it reused onsite. The illustrated steps allow to preserve the material resources in a limited perimeter, avoiding as much as possible the energy inputs and the emissions linked to transportation and offsite recycling processes, as well as the ones that would be induced by the manufacturing of new building products and their supply to the construction site[9]. Moreover, by preserving the integrity of several components, such as the portions of the external walls (Fig. 7) and the windows included in the new façades, the material culture that produced them is preserved as well. Although in a minor degree, this objective is achieved also by crushing the exceeding bricks and using them as aggregate for part of the concrete in the new dwellings (a choice recalled by the colour and texture of the new walls). At the same time, the designed constructions fulfil all the current technical, structural, and functional requirements that would be expected by more conventionally built edifices.

By preserving materiality, texture, colour, and shape of the available resources, the adopted strategy makes it possible to preserve the material culture that moulded

Figure 8 | Example of the reuse of existing external walls 'in parts' to create new façades.

them and, at the same time, memory of the past for the local community (Fig. 8).

3.2 Nature-Based solutions results

The Nature-Based strategy frames the issue of preservation within a wider perspective aimed at avoiding the consumption of resources, both built and non-renewable ones, while adopting an ecologic approach that integrates environmental objectives in the overall layout design. The steps to implement this strategy are:

- The conservation, through the necessary retrofitting, of the six existing buildings.
- The reorganisation of the dwellings' layout to respond to new functional needs, ensuring both larger internal spaces and new private outdoor areas.
- The reinforcement of existing structures to respond to nowadays requirements, also considering the new layout entailing a superelevation.
- The renovation to provide necessary energy efficiency improvements of the social housing complex.

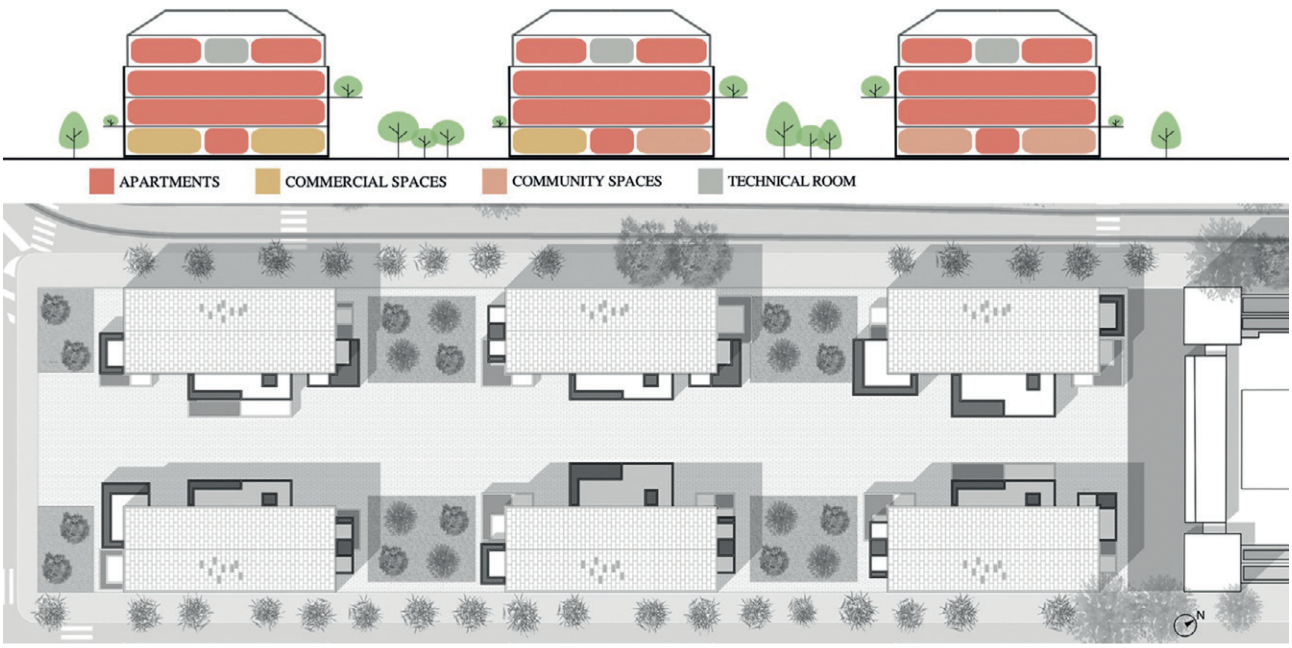

Figure 9 | Functional section displaying the uses of the different spaces and urban layout (NBS).

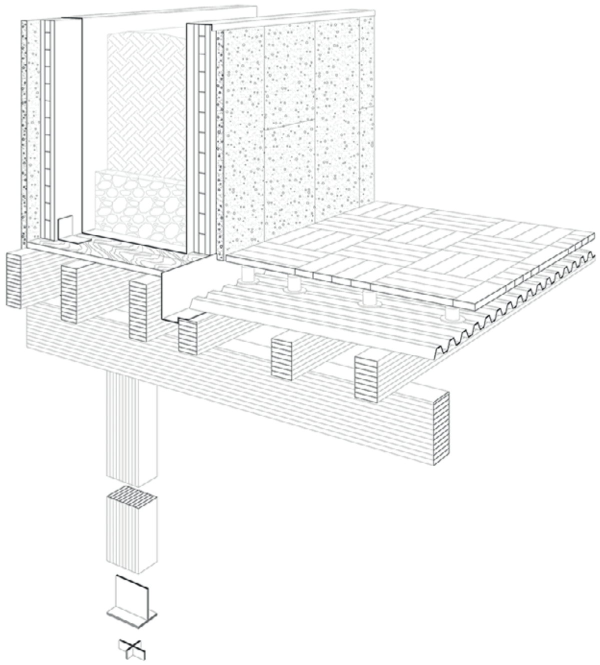

Figure 10 | Private terrace detail.

- The implementation of both private and public green spaces to obtain a more natural urban ecosystem.
- Declaring through both design and material choices the ecological perspective.

To improve the usability of the dwellings, the project envisages the extension of existing spaces through two different additions. A new volume increases the height of the buildings of one floor allowing a larger residential area, and private garden terraces, positioned on several levels with different layouts enrich both the housing layout and facades (Fig. 9).

On the structural side, engineered wood is used, and the additions are conceived together with the necessary structural adaptation, obtained through integrative wooden beams, which support the existing slabs and cooperate with the new terraces' external framework (Fig. 10).

Energy efficiency is achieved by insulating the existing walls of the dwellings both internally, with hemp fibres bricks, and externally, with a double layer of cork panels used for the cladding. A heat pump conditioning system replaces the existing and inefficient heating one, and its external equipment is arranged in a dedicated space in the new volume at the top of each building, guaranteeing the installation to be architecturally concealed.

The main challenge of this project, given the will of only using Nature-Based materials, is to find alternatives to plastic-based components, conventionally crucial for several building aspects among which the waterproofing of structures, achieved, in this case, by using metal elements such as corrugated metal sheets.

Figure 11 | Green private and public spaces.

Although these design choices appear to only address technical issues, they also consider the cultural and urban integration aspects. A diversified approach is adopted for treating the cork cladding: the lower part, which insulates and protects the existing brick walls, is finished with a cocciopesto plaster to be made by recycling terracotta from the removal of the existing roofing; in the upper part, cladding the attic, the panels are left exposed. This twofold choice means both to make the extension operation clear in relation to the recovery project, and to show and communicate how the building's renovation took place mainly using renewable materials. The shrubs used in the terraces were chosen to support biodiversity, most of all bees' highways, and many plants enrich the renewed public space as a green boulevard. Private gardens provide external space for the dwellings on the ground floor.

Through the Nature-Based strategy, the preservation of material and non-renewable resources is merged with the will to create an urban ecosystem, increasing the consciousness of environmental topics in the community, and providing green private and public spaces (Fig. 11).

3.3 Design for Adaptability principles results

Applying the DfA principles to the renovation of the existing buildings which, due to their topological, material, and tectonic conformation, are poorly adaptable, may seem inconsistent. On the other hand, the outcome of the design experimentation allows to approach the aim of the strategy from a different point of view, since it combines the opportunity of preserving the existing buildings, and their peculiarities, to a suited answer to contemporary needs. The DfA strategy envisages different interventions:

- The conservation, through the necessary retrofitting, of four of the six buildings.
- The reorganisation of existing interior spaces to respond to current functional needs, and to allow future flexibility.
- The reinforcement of existing structures to respond to nowadays requirements, also considering the new volumes.
- The energy efficiency adaptation, both through adding insulation in the building envelope of the original social housing complex and an upgrade of the plants.
- The design of new volumes according to DfD principles, allowing more cycles of reuse.
- The creation of a continuous urban front, which guarantees a protected pedestrian space in the inner court.
- The extension of the existing public green space by providing a new garden in the site of the two demolished buildings.

A new spatial layout is ensured through the new volumes, where both vertical connections and main technical installations are located. The internal partitions of the existing buildings are demolished and replaced by new, flexible ones. Communal spaces of living are imagined within the new constructions, as they can be reorganised

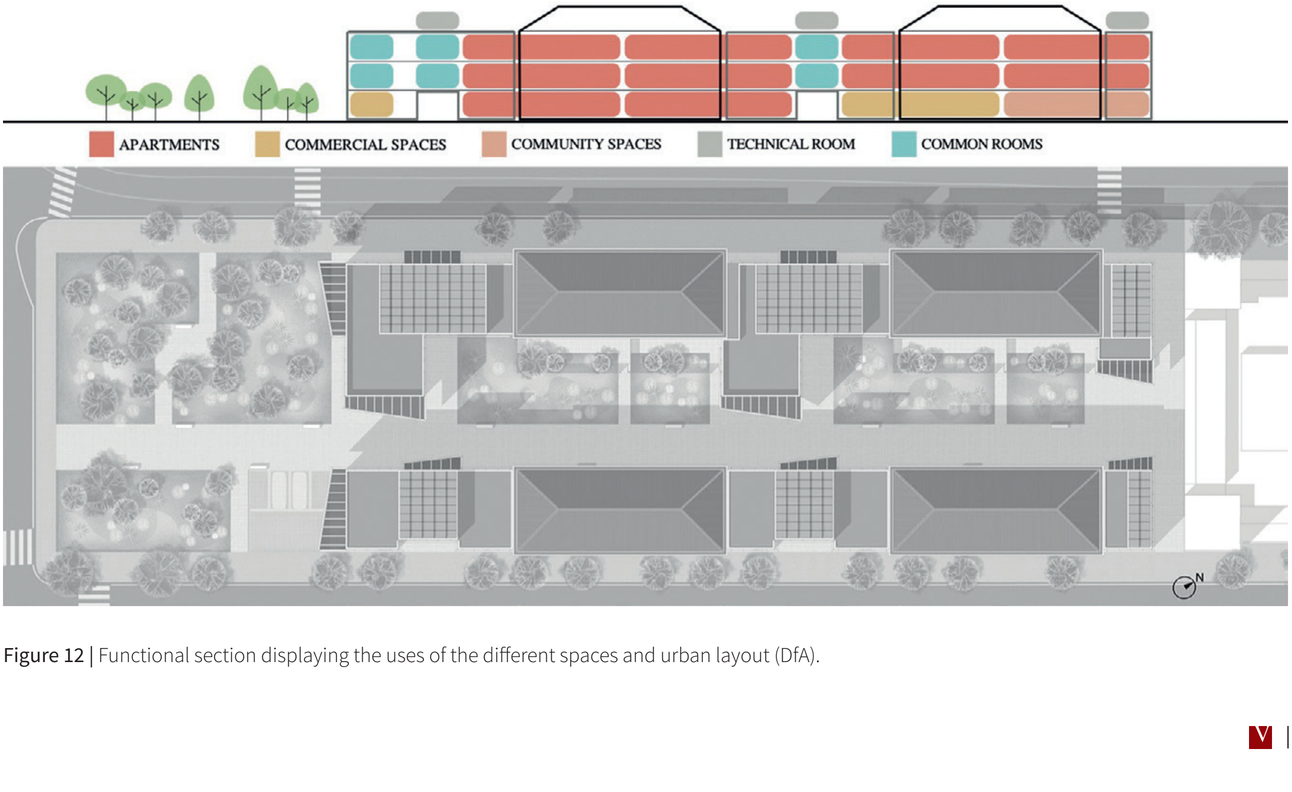

Figure 12 | Functional section displaying the uses of the different spaces and urban layout (DfA).

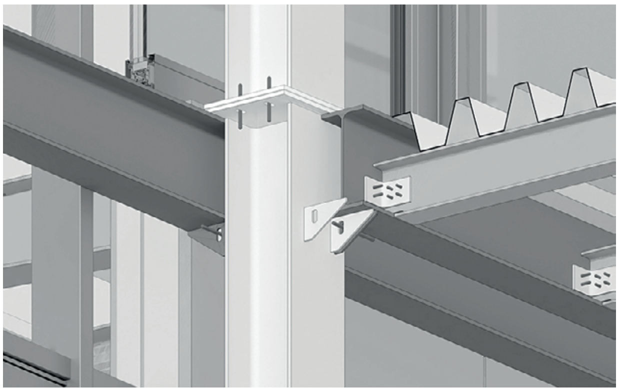

Figure 13 | Detail of the prefabricated and fully disassemblable steel system.

to become private spaces by moving the units' entrances. The dwellings' indoor residential areas, less subject to change over time, are located within the existing buildings (Fig. 12). This approach reflects on the external envelope as well. While the plaster finish of the existing buildings is preserved, the new volumes' façade system is designed to be modular and interchangeable, with opaque and transparent portions. A second layer is added to regulate natural ventilation and solar radiation. The adaptability of the envelope, in the new volumes, and of the internal subdivisions, for both new and existing buildings, facilitates todays and tomorrow's management of both.

The load-bearing structure of the pre-existing buildings is improved, while minor adjustments are made to create

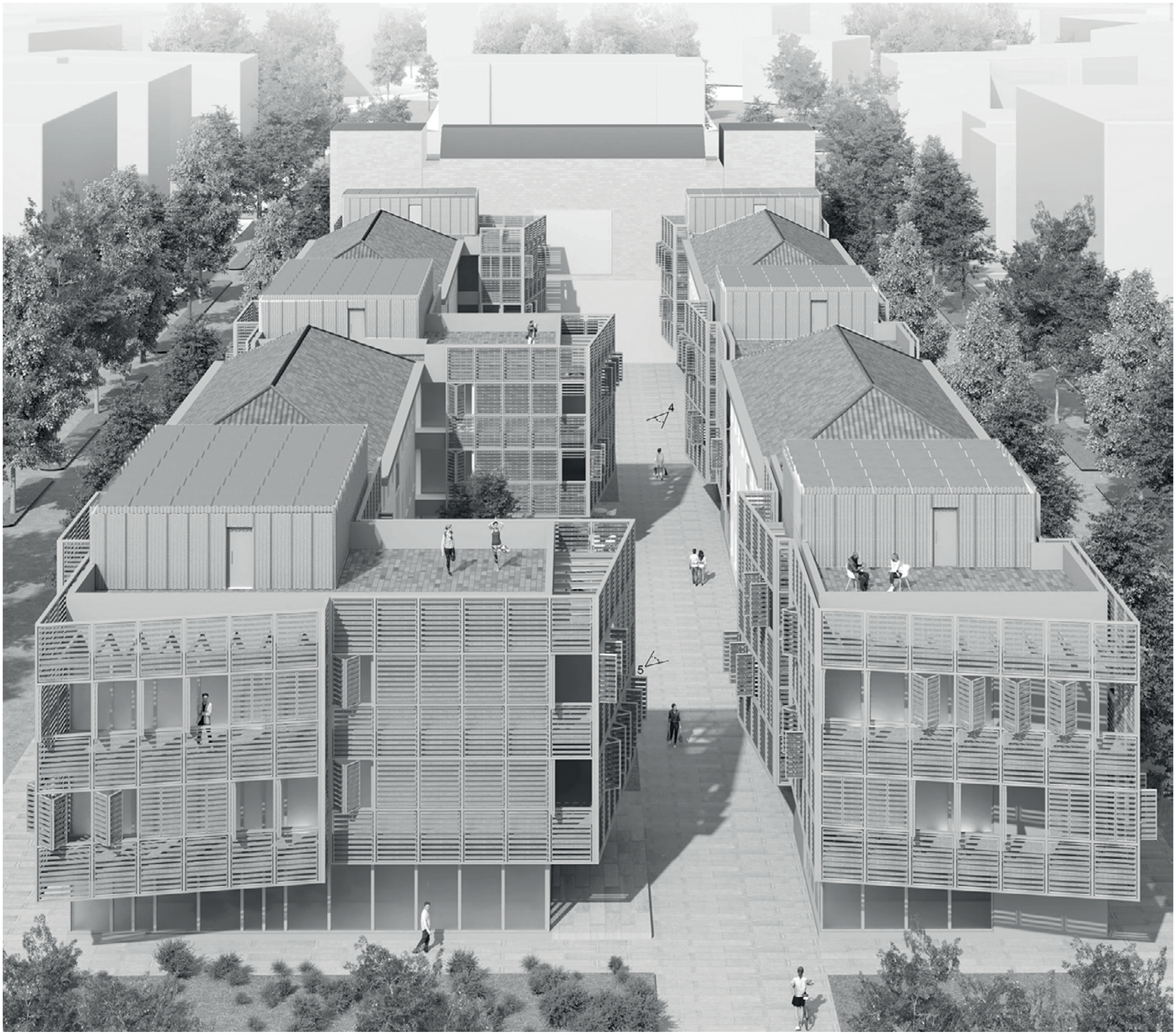

Figure 14 | New buildings present different finish and shapes to better frame public and private spaces.

loggias, and to better connect each volume with the new ones. The new volumes are designed with a prefabricated and fully disassemblable steel system (Fig. 13): besides and End-of-Life management concern, this choice addresses the technological features, located within suspended ceilings and lightweight infill walls, allowing them to be more easily modified over time.

Such approach is a key feature of the DfA strategy: since the existing buildings are made of solid brick masonry and rib and block suspended floors, the new ones are dedicated to vertical connections and technological elements. In fact, all plants, excluding internal distributions, are positioned in the new buildings. The technical rooms are located on the top level of such volumes, and vertical technical cavities allow the main distribution on each floor through separate distribution lines. This redundant system is based on the idea of keeping the highest grade of future flexibility for both the HVAC and electrical systems. Existing buildings are insulated from the inside by using well established techniques, so as not to compromise the materiality and traces of time on the external surfaces which, as abovementioned, are restored.

Through this approach to the DfA strategy it is possible to preserve, almost completely, the material resources of existing buildings, while creating more functional private and public spaces for today's needs, and the applied design guarantees flexibility over time if needs change. At the same time, by renewing existing buildings and implementing urban spaces with green areas and services for the community, both material culture and social message are preserved and enhanced (Fig. 14).

4. Conclusions

This contribution shows how, to tackle social housing rehabilitation issues, it is possible to overcome the traditional economic standpoint, which usually recurs to destructive demolition and subsequent construction of new buildings. By adopting a comprehensive sustainability view, the demolition's negative effects are framed in a broader boundary, and alternatives to avoid the loss of material resources, material culture, and social message, considering their ecologic, social and cultural consequences, must be examined. The illustrated research explored this topic through the implementation of three different design strategies (Urban Mining processes, Nature-Based solutions, and Design for Adaptability principles), the result of which are discussed and summarised below.

Regarding the first considered issue, the loss of material resources, each of the three strategies can reduce it, by different means. The Urban Mining approach envisages a deconstruction rather than a demolition to preserve the existing resources with the aim of reusing them in the construction of new buildings; its application to the case study proved that it appears a viable way since 73% of the materials were recycled and 13% were reclaimed, both onsite. The Nature-Based strategy does not perform demolitions, but rather preserves the six social housing buildings in their entirety, while reinforcing them structurally and using renewable materials for energy improvements, internal reorganizations, and volume additions. The DfA strategy minimises the loss of resources by preserving almost all existing buildings and their components and envisages a disassemblable structure to cope with the need to reduce new materials' supply over time. In all three applications a high level of attention was given to the chosen materials, both to reduce their supply impact and towards a future opportunity of dismantling the structures, if needed.

The loss of material culture becomes an important reason to preserve the constructive elements which, in their entirety, embody the formal and technical features of the material culture that shaped them. Within their implementation to the case study, the three strategies were able to address this aspect as well. Through the disassembling per portions implemented by Urban Mining processes, it is possible to preserve the morphological and material features of the existing buildings, despite their new reassembling: although the structures are new, their external envelope 'embodies' the memory of the past through the reclaimed elements. The Nature-Based strategy completely preserves the existing buildings, while at the same time improving the usability of the residential spaces thanks to the increase in volume with the addition of a storey. Moreover, the new cocciopesto finish allows to further enhance the historical memory of traditional construction techniques. The DfA approach fully preserved the exterior appearance of the conserved existing buildings, together with the material resources they are made of, and the new additions present a completely different finishing to distinguish the historic social dwellings from the new ones.

Concerning the loss of a social message, the three illustrated strategies managed, by different means and by achieving different results, to minimise this loss through conservation processes that allowed the trace of the social housing complex to endure in the urban fabric. With the Urban Mining strategy, this retaining approach was applied by preserving the material textures, colours, and shapes by either the onsite reuse of components or onsite recycling. Therefore, the community can still recognise the elements which for decades have been part of the historical and social development of the area since they are integrated into the newly designed buildings. The Nature-Based strategy represents the most conservative approach in these terms. Through renovating all the buildings belonging to the social housing complex it preserved the community historical memory, while adding a clearly recognisable storey on the top with some private green spaces to respond to residents' current needs. The DfA strategy places itself halfway between the other two, since it does not preserve all the six buildings but, thanks to the possibility of exploiting the technical and performance characteristics of new volumes, it envisages a means to give innovative value to the existing built environment.

Each strategy produces specific benefits. The Urban Mining one, adopting a 'deconstruction and reassembly' pattern, appears akin to the conventional 'demolition and construction' process. Therefore, it can be more easily taken into account by public institutions. The Nature-Based approach brings both energetic and functional benefits, while preserving the different considered aspects. By significantly enhancing private green spaces, it both values the residents' needs and contributes to create an urban green ecosystem. Lastly, the DfA strategy, besides meeting the expected requirements, guarantees more flexibility to the complex over time, maximising its future potential use, and provides large public open spaces.

The application of the illustrated strategies to the case study of Marghera thus shows that a wider sustainable perspective on the rehabilitation of existing social housing is indeed possible. Such more comprehensive approach would not only allow for energetically sustainable buildings, but it would also improve the quality of the spaces at service of the community, creating places having material substance, shape, texture, and colour, (Norberg-Schulz, 1979) that determine a cultural and social environmental character. Social housing represents an important percentage of existing dwellings in European urban areas, and their rehabilitation through demolition would drastically change whole neighbourhoods' appearance and ways of living them. Nevertheless, even though it is possible to reach significant sustainable results by applying the selected strategies, due to their explorative nature and the site-specific application, some improvements can still be performed and other patterns examined, taking into account the economic matters as well. Hence, further analysis on the topic is needed.

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Notes

1. DM 22 aprile 2008 defines social housing as: '[…] unit for residential use on a permanent lease that fulfils the function of general interest, in safeguarding social cohesion, of reducing the housing hardship of disadvantaged individuals and households, who are unable to access rental housing on the open market. Social housing is an essential element of the social housing system consisting of all housing services aimed at satisfying basic needs. It is a form of housing that, while also meeting the economic difficulties of many people, encourages socialising and sharing. The European Commission, however, defines Social Housing projects as aiming to rent or sell housing at affordable prices to people who are, at the time, in various conditions of hardship or difficulty, even temporary.'
2. https://www.ledauphine.com/isere-sud/2019/09/30/le-ric-de-la-villeneuve-devrait-avoir-lieu-en-octobre
3. https://londontenants.org/publication/23000-social-rented-homes-were-demolished-in-london-over-the-last-ten-years-2012-2022/
4. https://jyllands-posten.dk/uknews/ECE5012218/Rioting-at-Christiania-follows-demolition/
5. https://mattinopadova.gelocal.it/padova/cronaca/2020/08/29/news/addio-bronx-di-padova-via-anelli-story-1.39244116
6. https://davosdeclaration2018.ch/
7. https://www.ace-cae.eu/uploads/tx_jidocumentsview/LEEUWARDEN_STATEMENT_FINAL_EN-NEW.pdf
8. https://www.veneziatoday.it/cronaca/protesta-marghera-chiusura-case-popolari.html
9. An in-depth analytical investigation of this process, providing data based on ecological, social, and economic parameters, can be found at the following link: https://doi.org/10.1080/09613218.2022.2093153

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