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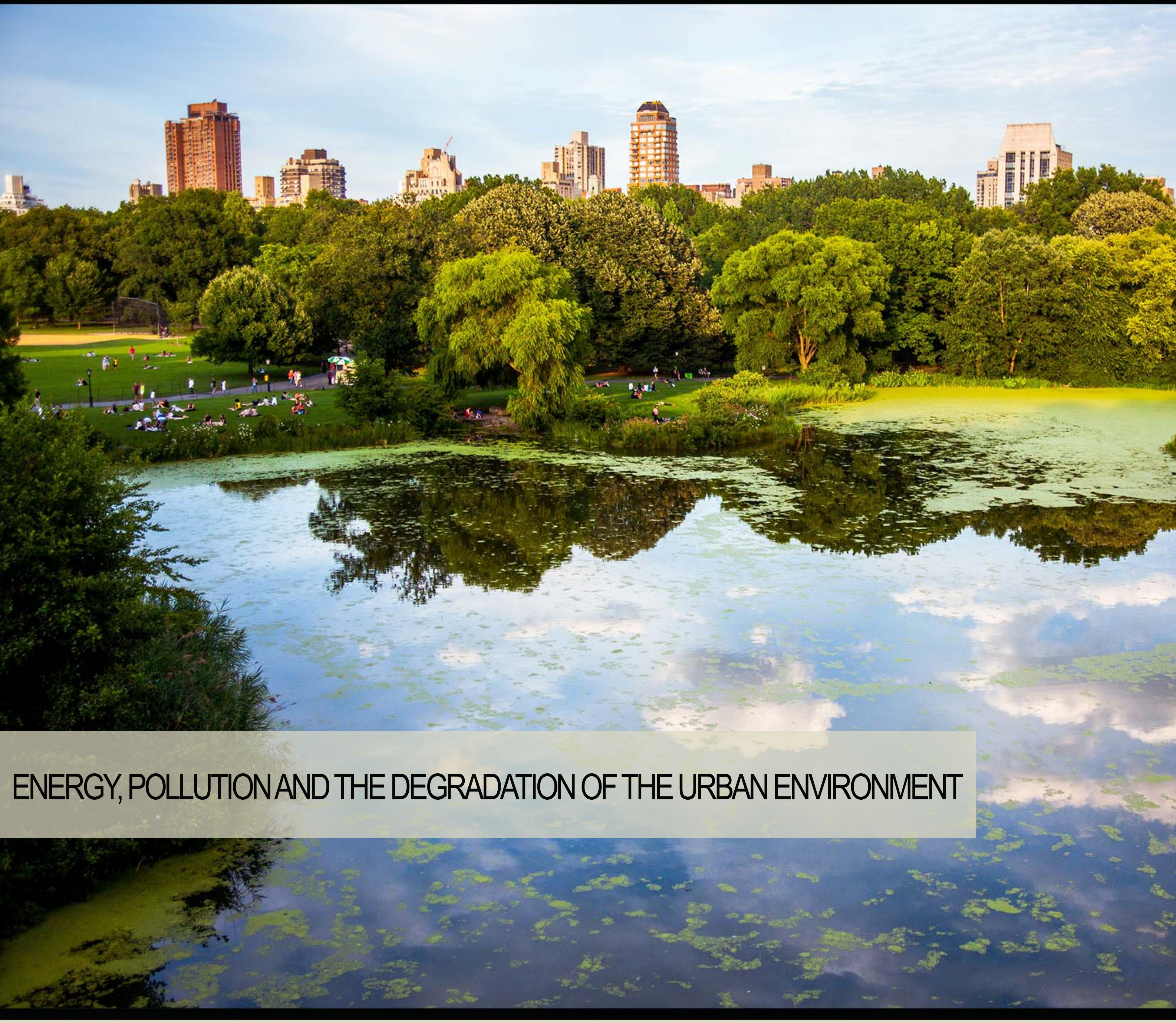

ENERGY, POLLUTION AND THE DEGRADATION OF THE URBAN ENVIRONMENT

Vol.9 n.2 August 2016

print ISSN 1970-9889 e-ISSN 1970-9870
University of Naples Federico II

TeMA

Journal of
Land Use, Mobility and Environment

ENERGY, POLLUTION AND THE DEGRADATION OF THE URBAN ENVIRONMENT

2 (2016)

Published by
Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"

TeMA is realized by CAB - Center for Libraries at “Federico II” University of Naples using Open Journal System

Editor-in-chief: Rocco Papa
print ISSN 1970-9889 | on line ISSN 1970-9870
Lycence: Cancelleria del Tribunale di Napoli, n° 6 of 29/01/2008

Editorial correspondence
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Cover Image: “New York, New York” by Hector Arguello Canals. Retrieved at: https://unsplash.com/photos/2x6vURol6cM.

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TeMA
Journal of
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TeMA 2 (2016) 05-30
print ISSN 1970-9889, e- ISSN 1970-9870
DOI: 10.6092/1970-9870/3922

review paper received 13 May 2016, accepted 14 July 2016

www.tema.unina.it

How to cite item in APA format:
Gargiulo, C., Lombardi, C. (2016). Urban Retrofit and Resilience. The challenge of Energy Efficiency and Vulnerability. *Tema. Journal of Land Use, Mobility and Environment*, 9 (2), 5-30. doi: http://10.6092/1970-9870/3922

URBAN RETROFIT AND RESILIENCE:

THE CHALLENGE OF ENERGY EFFICIENCY AND VULNERABILITY

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ABSTRACT

Urban retrofit is becoming increasingly established as one of the most effective solutions to contain the energy consumption of the existing building stock, to reduce vulnerability to natural and man-made risk and generally improve the quality of built space. However, the planning of retrofit interventions at urban scale should take account of the actual feasibility of measures lest they remain only on paper.
This contribution supplies an overview of the many issues related to the subject of urban regeneration, proposing a procedure to identify practical interventions to minimize costs and maximize benefits, in terms of energy efficiency, an increase in resilience and improvement in the quality of the building stock. This procedure was applied to a case study of a neighborhood in the city of Naples, a high-density urban area which is particularly vulnerable to volcanic and seismic risk, and to risks due to climate change.

KEYWORDS:
Retrofit; resilience, urban vulnerability, property enhancement, energy efficiency.

TeMA

有关土地使用、交通和环境的杂志

TeMA 2 (2016) 05-30
print ISSN 1970-9889, e- ISSN 1970-9870
DOI: 10.6092/1970-9870/3922

review paper received 13 May 2016, accepted 14 July 2016

www.tema.unina.it

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城市翻新和适应力:

能源效率和脆弱性方面的挑战

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摘要

城市翻新正日益成为控制现有建筑群的能源效率、降低对自然和认为风险的脆弱性以及从整体上改善建筑空间质量的最有效解决方案之一。但是，城市范围内的翻新干预计划要考虑措施的实际可信性，以免它们只存在于纸面上。本文概括了与城市改造话题有关的一些问题，并提出了一个用于识别实用干预措施的程序，从而在能源效率、提高适应力以及改善建筑群质量方面实现成本的最小化和效益的最大化。该程序应用于那不勒斯某街区的案例分析中，这是一个高密度的市区，特别是易遭受火山、地震及气候变风险。

关键词:
翻新、适应力、城市脆弱性、房屋加固、能源效率

1 INTRODUCTION

In recent years, the reduction in energy consumption has assumed a strategic role in development models for cities and urban communities in the industrialized West. On the one hand, the economic crisis and on the other, the consequences of climate change have driven technicians and researchers to study these phenomena with the aim of setting up concrete, workable solutions (approaches, methods, procedures, policies, etc.) in the short and medium term (Hulme et al., 2002).

According to the international scientific community, environmental sustainability and energy efficiency today represent two cardinal points on which to build cities and society in the immediate future. Yet is making a city energy-efficient in an area which is vulnerable to natural risks enough to make it really sustainable? The IPCC's Fifth World Report (IPCC, 2013) shows the strict linkage between global warming due to greenhouse gas emissions and destructive climatic events such as floods, water bombs, heat waves and drought. And if cities are the places with the highest carbon footprint (Newman, Kenworthy, 1995), they are also places where the risk of natural and/or man-made events with catastrophic consequences is also highest (Galderisi, 2014).

The possibility of concretely inverting the current trend and formulating a model of sustainable development has to take into account, also in the presence of a drastic reduction in polluting emissions, the pervasiveness and frequency of humankind's actions *vis-à-vis* planetary warming in recent decades (EC, 2013). Alongside mitigation interventions, it is necessary that substantial "adaptation" measures of urban systems to climate change be set in train. However, the risks linked to rapid climate change under way are not the only threat to the safety of cities. There are whole regions which, due to their geographical location, have always been exposed to other types of natural risks such as seismic risk and volcanic risk. The building stock in such areas is unsuited to dealing with such events, in so far as most of the buildings existing in Europe and North America were erected before the introduction of legislation to reduce constructional vulnerability (Cheung et al., 2001; Clemente, 2013). Further, the existing building stock, which is old, poorly maintained and inefficiently constructed (Van der Heijden, 2014), is responsible for 40% of primary energy consumption (Baker & Steemers, 2000). This is attested by the spread of retrofit practices to renovate and improve the existing building stock (Dixon & Eames, 2013). Clearly, the complexity and extent of the challenge facing cities in the near future cannot be solved without a holistic approach to the issues of energy saving, adaptation to climate change and a reduction in urban vulnerability to natural and man-made risks. These are matters of enormous social and economic importance which affect millions of buildings and which entail very high costs, costs which cannot be met by public resources alone. It is also widely held that sums invested to reduce energy consumption have excessively long economic return times (Jones et al., 2013) and that interventions to reduce vulnerability do not significantly increase the market value of the real estate involved (Erdik, 2002). In both cases we are dealing with somewhat unattractive investments since they are conditioned by slow and scant financial returns. On the other hand, it is worthy underline that as stated in the 7th chapter of the Fifth Assessment Report on Climate Change, there is a limited number of research on «the effectiveness and cost-efficiency of climate related energy policies and especially concerning their interaction with other policies in the energy sector» (IPCC, 2014). Ultimately, to ensure the concrete feasibility of interventions which are presented as necessary, it is worth setting up intervention programs and integrated sets of works which consider not only the reduction in energy consumption and resilience to natural and man-made risks, but also the increase in value of the existing building stock, allowing, for example, for increases in the volumes of existing structures, changes in use, and significant interventions on overall urban quality. This contribution aims to provide a coherent framework of the latest scientific advancements which study the types of intervention to improve energy efficiency, whether in the construction field or in city planning and, at the same time, promote energy saving, to significantly enhance the capacity of cities to cope with extreme events, with a holistic approach and in a context of operational integration which is rarely applied. In the second part of the paper, in light of the considerations made, a case study is examined so as to verify in the field the effectiveness of the procedure proposed: a neighborhood in an area subject to various natural risks. The factors contributing to the various phenomena in question are analyzed, proposing an illustrative program of interventions that integrate energy efficiency and reduction in urban vulnerability from the standpoint of real estate enhancement, with the aim of improving the quality of the context for which the urban retrofit intervention is proposed.

1.2 STATE OF THE ART

Although in the last few decades many efforts have focused on defining measures to reduce consumption at the building scale, only recently has there been increased awareness of the need to undertake measures at the urban scale (Dunham-Jones & Williamson, 2008; Dixon & Eames, 2013, Papa et al., 2016). Isolated episodes of energy savings in buildings, albeit successful, have proved insufficient to respond concretely to the problem. It is not only a question of size: to think that such interventions can be scaled up automatically to the urban context overlooks the complexity of the matter (Dixon et al., 2014). Indeed, it is now widely held that the urban form and especially its settlement density greatly affect energy consumption (Owen, 1986, Papa et al., 2016), as confirmed in the 12th chapter of the IPCC's Fifth Assessment Report, which highlights that «the urban scale also provides unique opportunities for policy integration between urban form and density, infrastructure planning, and demand management options» (IPCC, 2014).

As for the relationship between urban texture and energy consumption, Ratti, Baker and Steemers (2005), conducted a study focusing on the design, construction and occupational performance within three cities: London, Toulouse and Berlin. This research give an insight on how urban morphology plays a determinant role in the definition of energy consumption. They provided a predicting model to verify which parameter could describe best the relationship between urban form and energy consumption and suggest that passive to non-passive indicator is more suitable for this purpose than surface-to-volume ratio at the urban scale.

A study conducted by a French research group (Maïzia et al., 2009) into 18 types of building aggregations in six different cities in France showed that the benefits which may be conferred by a compact urban form are much more limited than is generally thought. Rather, there emerged the close correlation between building density and exposure: it was shown that the effects of compactness are more significant in new settlements, where building orientation may be optimized according to heat gains, than in historic aggregations.

From another research conducted in 2001 in Hong Kong (Hui et al., 2001) emerges that there is no single formula to obtain an energy efficient urban form. Urban "densification", indeed, may have both positive and negative effects on total energy demand: if on the one hand the concentration of buildings makes the application of solar collectors and PV power systems more difficult, on the other dense urban fabric enables to optimize renewable energy resources.

However, the spatial organization of a settlement, does not only affect energy consumption. Indeed, with reference to the relationship between urban form and climate change, various contributions (Givoni, 1989; Cervero & Kokelman, 1997, Holden & Norlan, 2005, Salat & Nowacki, 2010) have shown that urban form affects the particular microclimate which is perceived inside a settlement and which is the subject of a specific discipline termed "urban climatology". Of these, two researchers from the University of Manchester (Smith and Levermore, 2008) explain how the effects of global warming are more greatly felt in urban areas due to the lack of night-time cooling, the scarcity of vegetation and overheating due to human activities. Moreover, compactness may cause an increase in the "heat island" effect in so far it not only limits the flow of winds but also increases the concentration of radiation due to albedo.

As regards measures of adaptation to climate change, it must be take into account that, as mentioned before, global warming produces not only direct effects on temperature: one of the most worrying consequences is the sea level rise that, between 1901 and 2010, has been estimated on average 19 cm, i.e. more than the average rate of the last two millennia (IPCC, 2013). Not only, also the contrast of the amount of precipitations among regions and between wet and dry seasons has increasingly intensified, causing extreme events such as heat waves, droughts and flash floods. In this context, several cities which are particularly vulnerable to environmental risk are equipped with plans of adaptation to climate change, with a view to protecting their own citizens from catastrophic events and continuing to enable their economies to prosper. Of these cities, in 2012 Rotterdam, with its long tradition of coping with difficult environmental contexts, drew up the Climate Change Adaptation Strategy (2012), which aims to map out development paths that adapt to the various effects of climate change, from the increase in sea level to heat waves, obtaining at the same time maximum benefits from interventions. The most interesting aspect is cost minimization, envisaging the systematic implementation of adaptation measures whilst carrying out maintenance works and making changes, seeking to maximize benefits in economic terms, both as regards suitable potential businesses for the area, and especially in terms of urban quality and an increase in the market value of building stock.

With regard to reducing the seismic vulnerability of buildings, the economic factor is of fundamental importance for implementing interventions, as shown by the study carried out by two researchers from the Department of Seismic Engineering of Bogazici University, Istanbul, estimating the possible damage to the building stock after a strong earthquake (Erdik, 2002). According to the above study, the cost of possible interventions of overall retrofit to reduce building vulnerability would amount to as much as 40% of the replacement value, also entailing disruption due to the evacuation of lodgings for several months. At the same time, it was ascertained that retrofit measures do not increase the market value or rental value of property. Therefore, for the owners it would be an investment without financial returns, and any incentive for private property owners to implement interventions is likely to have little effect. Nevertheless, the benefits in terms of safeguard of human lives and savings in social costs arising from a probable earthquake, would accrue to the whole community. A practicable route is to restrict the field of action, mapping particularly vulnerable buildings and infrastructures and intervening first and foremost on them (Polese et al., 2008). For this purpose, the "Preliminary Study of Instruments to Apply Seismic Regulations in Historic Centers", drawn up by the Higher Council for Public Works (CONSUP, 2012), proposes a multi-dimensional assessment of urban vulnerability. In other words, on the one hand, the direct vulnerability of buildings and infrastructures is assessed, i.e. the likelihood of seismic damage resulting, for example, from the construction year, from building flaws, from the geo-morphological state of the subsoil able to amplify seismic effects. On the other, seismic behavior is assessed, considering the city as an urban system, thus taking account of the hierarchical and territorial role of the system's individual components, which bring about a different level of exposure not only of individual units but of the whole urban system or some of its subsystems. Consider, for example, the strategic role of a hospital or business district, or the concentration of people in a certain moment of the day in a historic centre, or at a given time of year in a holiday resort. Thus, according to the CONSUP, the levels of damage vulnerability of a city may be estimated through a combination of assessments of each functional subsystem, thereby restoring the overall level of vulnerability (Cremonini, 2015).

As regards reducing vulnerability to volcanic risk, extensive research confirms the importance of identifying particularly vulnerable contexts, both for planning consolidation interventions and for drawing up possible evacuation plans (Corradi et al., 2015). In this context, in recent years, PLINIUS Study Centre of the University of Naples has set down a simulation model to estimate, in probabilistic terms, the direct and indirect economic impacts of Type 1 sub-Plinian eruptions of Mt Vesuvius and the volcanic complex of the Campi Flegrei (Zuccaro et al.,2013). Such impacts have been compared to those of similar scenarios which, however, envision risk mitigation interventions such as the seismic adaptation of buildings facing onto escape routes, consolidation of roofing to protect from damage from falling ash and the protection of particular strategic buildings. "Avoided risk", corresponding to the cost of reconstruction, would amount to billions of euros against mitigation interventions at a cost at least one order of magnitude lower. Restricting the field to particularly vulnerable units is an essential step forward but it does not automatically ensure that measures are implemented. In consideration of the approaches proposed by the above research projects on the relationship between the urban form and energy consumption, between urban form and climate change and, further, on the relationship between city and vulnerability to climatic, seismic and volcanic risk, an experiment was conducted, as reported herein, on a state residential building complex. Intervention classes are proposed to reduce consumption, vulnerability to climatic volcanic and seismic risk, which, at the same time, take account of aspects related to the microclimatic welfare of dwellings, urban quality and the creation of economic value of the existing building stock.

2 RETROFIT MEASURES: A REVIEW

To answer the above questions, we propose a review of retrofit measures set up and tested in various environmental contexts worldwide. With regard to measures to reduce vulnerability to risks connected to climate variations, they considerably vary according to the effect to tackle, related to the specific territorial context of the settlement. Indeed, there are four main effects directly or indirectly connected to global warming: floods, flash floods, heat waves and droughts, which can often weaken the yet uncertain balance of urban ecosystems. Each of these effects can be addressed through specific measures for each territorial context, which can be often reduced to a few integrated actions. It is worthy underline that each intervention should include not only the reduction of risk during the event, minimizing economic and social costs, but also should improve the recovering capacity after the disturbance (resilience).

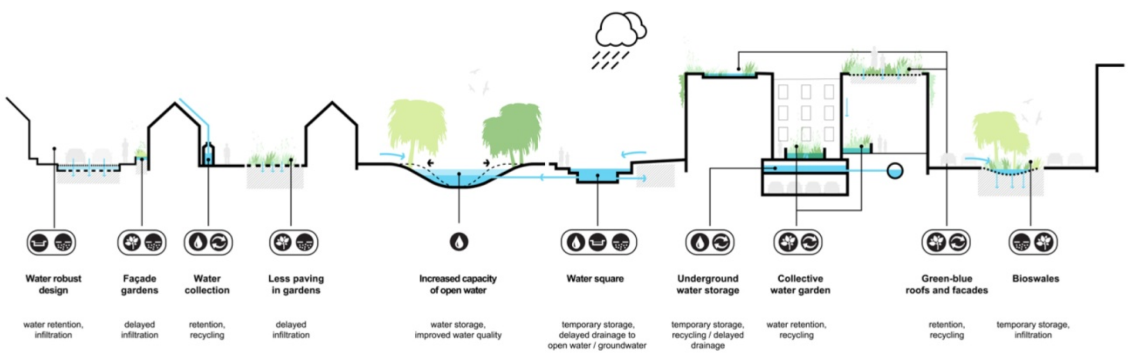
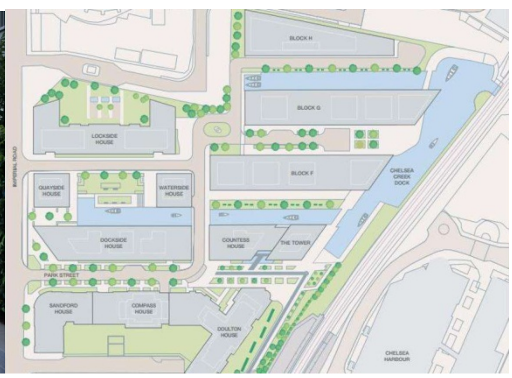


Fig. 1 Scheme for the catchment and reuse of rainwater drawn up in the Rotterdam Adaptation Plan

Figs. 2 and 3 Chelseacreek (London), 2015. View of one of the accesses to habitations and Masterplan it is generally possible to use the term "blue-green" measures to describe this group of measures (Voskamp & Van de Ven, 2015), i.e. the set of interventions to increase the permeable surface of constructed spaces (roads, squares, roofs and facades of buildings), creating systems of rainwater catchment, storage and disposal. Indeed, the ever-increasing extremes of seasonal climatic events entails the occurrence, in the same geographical context, of abundant rainfall in very short times during the wet seasons and, in parallel, the total absence of rainfall for very long periods during dry seasons. Creating interventions which mitigate this temporal variation in water availability means, amongst other things, increasing the infiltration capacity and the channeling of water into suitably designed places, which may be positioned both in open spaces, like water squares or small channels, and in underground storage places or in outdoor tanks. If properly applied, such measures could, on the one hand, avoid flooding in the event of intense rainfall and, on the other, allow the re-use of stored water for hygiene purposes or for irrigation and also ensure storage to mitigate temperatures when there is little or no rainfall.

With regard to the possibility of reducing the impacts of a natural seismic or volcanic event, it might be rightly pointed out that it is not possible, at present, acting on its hazard, i.e. on the likelihood that an event occurs with a certain intensity, over a certain time, contrary to climate-related risks, for which it is possible to plan mitigation measures, though in the long terms. Humankind can only affect vulnerability of urban systems, (primarily buildings and infrastructures), i.e. on their inclination to damage and exposure, i.e. on the quantity and quality of man-made elements exposed to a seismic event, including population (Corradi et al., 2015). Measures to reduce risk are thus aligned on these two pathways, planning interventions to reduce the risk assessed on the basis of these two possible expected scenarios. Measures to be implemented will generally have to upgrade the existing stock of building and infrastructure to meet new safety standards or at least ensure acceptable levels of structural resistance to protect persons and goods, through structural improvement and retrofit (Clemente, 2013). Conversely, measures to reduce exposure aim at limiting concentration of people and activities in vulnerable places to natural events. Since it is impossible to limit human activities and concentration of people, it is necessary to analyze the functional organization of settlements and locate activities in sites which are geographically not exposed to a possible natural event (Cremonini, 2015). Another important action regards the improvement of emergency services to favor first rescue, both by means of “Early Warning” systems and the improvement of evacuation systems. If, as already mentioned, in order to reduce urban vulnerability, a mapping of the vulnerable buildings is fundamental (“domography”), to encourage rescue operations it may be useful a mapping of vulnerable people residing in a territory exposed to natural hazards (“demography”), planning special interventions in places where old and disable people are more concentrated (Corradi et al., 2015).

The main measures to reduce vulnerability to seismic risk concern consolidation and seismic adaptation (retrofit) using technologies to improve the response of structural elements to the earthquake (Giovinazzi et al., 2006), taking due note of the particularities of each building (Zuccaro et al., 2013), and/or modify the geo-morphological conditions of the subsoil which come into play in the seismic acceleration expected (Barocci, 2015). Interventions in buildings chiefly consist in global or partial strengthening of structural parts (Cheung et al., 2007), while interventions in the subsoil aim to change the way in which seismic waves are propagated through the soil which, according to the specific stratigraphy, may appreciably amplify local effects (Lombardi, 2015). As regards setting up measures to contain volcanic risk, while it may be true that areas closest to the volcano cannot but make evacuation plans for the inhabitants and provide for the relocation of firms to safe areas, it is in the most outlying zones, subject to pyroclastic flows, that interventions to reduce vulnerability may actually have positive effects (INGV, 2012). Indeed, the phenomena that occur in phases prior to the eruption involve the need to remain indoors, sheltering from ash fall, which is why roofing consolidation becomes a fundamental measure to mitigate risk. Moreover, the hazard level may increase considerably due to the high probability of concurrent rains which could cause damage not only to the roofs of buildings but also to infrastructures of various types, such as the electricity grid, the telecommunications network, civil infrastructures (roads, railroads, airports and stations), as well as cause the blockage of the network for water provision and disposal. It is thus worth enhancing systems to protect infrastructures and provide for excess capacity of disposal systems so as not to diminish their performance in the event of ash fall and intense rainfall. In addition, sites need to be earmarked at some distance from urban areas, in which to store the ash temporarily once the event has run its course. Finally, the particular aspect of volcanic risk concerns combined vulnerability, i.e. the possibility that the eruption triggers collateral processes such as earth tremors, rainfall with dissolved pyroclastics, lahar, flooding and landslides, the latter months or even years after the eruption (INGV, 2012), which is why combined effects of the various risks need to be taken into account.

The review of interventions listed undoubtedly represents a set of essential and immediate measures, if one considers the results in terms of protecting human lives and goods. However, they should also meet people's everyday needs in terms of environmental comfort and quality of life in the relevant urban contexts. For this purpose, solutions are proposed to enhance perceived welfare and improve urban quality overall.

2.1 ENERGY SAVING, MICROCLIMATIC WELFARE, IMPROVEMENT IN QUALITY OF LIFE

In light of the considerations made in the sections above, we propose a review of possible interventions to improve the quality of life and microclimate welfare of city users whilst containing energy consumption. Indeed, setting up interventions and instruments able to control the urban microclimate allows the twofold objective to be achieved, i.e. save energy and enhance thermo-hygrometric welfare, thereby improving the quality of life of the citizenry. Generally speaking, one of the fundamental objectives is to mitigate temperature differences between urban and rural areas due to the heat island effect, thus maximizing benefits from the difference in temperature between day and night (Landsberg, 1981; Oke, 1987). Following a holistic approach, measures to control urban areas bioclimatically concern both urban design and aspects related to the performance of individual buildings (Smith & Levermore, 2008).

As regards the bioclimatic quality of the urban layout, the form of the settlement plays a fundamental role (Ratti et al., 2005). However, the mere orientation of buildings on the basis of the heliothermic axis may often lead to a relative rigidity in the layout of buildings. For this reason, at times, a radial geometry may for example be preferable to one with parallel rows, correcting unfavorable orientations by means of architectural and typological solutions (Dispoto, Gargiulo, 2015). Attention to prevailing winds may also profoundly affect both open spaces and welfare perceived within buildings, creating for example lines of trees for protection from prevailing winds or orientating road axes at an angle of 45° to the prevailing wind direction, interspersed with parks, green areas or water courses to enhance the cooling effect of the wind (Sandberg et al., 2003). Building design should take account of the compactness ratio (s/v) to limit dispersion, both of the correct arrangement of spaces and plant. Service spaces should be located to the North and the more inhabited environments to the South, as should the systems of energy production (solar heating panels, photovoltaic panels, energy roofs etc.). Although the reduction in energy consumption constitutes a major incentive to create the operations listed, the long return times of investments, especially as regards measures on the building shell, have resulted in a low propensity among owners to undertake interventions. It thus becomes necessary to introduce objectively feasible retrofit measures which can immediately generate economic benefits.

2.2 IMPROVEMENT IN URBAN QUALITY AND PROPERTY ENHANCEMENT

As already pointed out, the feasibility of the above interventions is strictly linked to the possibility of creating economic value which activates transformation processes at both building and urban scale. Among the activities that can best trigger such processes is the change in intended use and the increase in volume. The change in intended use is an interesting urban regeneration tool because it allows value creation without using other land. At the same time, it is possible to combine various types of intervention to mitigate vulnerability and save energy, which differ according to the intervention concerned: open spaces, ground floors, intermediate floors or the roof space of offices. This approach is actually recommended, taking into consideration that «well-designed systemic and cross-sectoral mitigation strategies are more cost-effective in cutting emissions than a focus on individual technologies and sectors» as stated in the Summary for Policymakers of the IPCC's Fifth Assessment Report (IPCC, 2014).

With regard to the ground floor, storage rooms can be converted into flats through insulation of the side walls and the flooring, thereby obtaining an improvement in heat/energy performance also in the floors above. By the same token, conversion of uninhabitable roof space into lofts represents a particularly interesting procedure especially in areas neighboring those affected by possible volcanic phenomena insofar as it would allow an improvement in the performance of the whole building through insulation of the horizontal upper closure, but could be combined with interventions to improve the load-bearing capacity of the roof. The increase in volume represents another important incentive for carrying out interventions. In particular, think of those interventions that do not involve further land use but that can provide important results in terms of optimizing heating gains: an example is the construction of south-facing solar greenhouses, with suitable screening, which maximize the contribution of the sun's rays both in winter and in summer.The expansion of flats would also be useful to improve the performance of the building in terms of the S/V ratio[1] and the benefits in terms of related energy saving. In sum, the retrofit measures identified represent solutions to specific needs to reduce risk, pursue objectives to improve urban quality and create economic value. The set of measures is organized schematically in Table 1.

OBJECTIVES	RISKS		SOLUTIONS	MEASURES
- Reduction in urban vulnerability	Climatic risks	Drought Water bombs Heat islands Floods	Increase in permeable surface area; catchment systems; rainwater storage and disposal	Green paving; creation of water courses/storage areas for water; green roofs; blue roofs; construction of safe havens for the disadvantaged; BEMS/Automatic warning systems
	Natural risks	Seismic risk	Improvement in behavior of buildings to earthquake; creation of safe havens	External support structures; increase in local resistance of structural elements; independent connection construction of safe havens for the disadvantaged; BEMS/Automatic warning systems; energy self-sufficiency systems
		Volcanic risk	Improvement in roof cover resistance; reduction in sewage overload; creation of safe havens	Structural improvement in roof cover for ash loads; creation of water collection sites in case of blockage; creation of ash accumulation sites; creation of safe havens for disadvantaged categories; BEMS/Automatic warning systems; energy self-sufficiency systems
- Improvement in quality of life - Improvement in microclimatic welfare - Energy saving			Improvement in shell insulation; control of natural vegetation; production of renewable energy; optimization of exposure	Screening; solar greenhouses; green roofs; solar chimneys; ventilation chimneys; heat insulation; ventilated walls; replacement of fixtures; replacement of boilers; photovoltaic panels; heat collectors; teleheating; green paving; creation of water courses/water storage sites
- Improvement in urban quality - Economic exploitation				Increase in volume; change in building use

Tab.1 Scheme of retrofit measures for each of the set objectives

1 S/V. A building with a low S/V value is considered desirable energy wise because it has a lower dispersive surface area per unit of usable space.

3 CASE STUDY: ANALYSIS OF VULNERABILITY AND ENERGY CONSUMPTION IN A NAPLES NEIGHBORHOOD

The brief and undoubtedly inexhaustive survey of interventions proposed constitutes a portfolio of possible applications to be combined according to environmental and socio-economic contexts. So as to be able to assess the benefits of such measures, in terms of performance improvement and response at the same time to various needs, the groupwork of the TeMALab laboratory of the Department of Civil, Architectural and Environmental Engineering (DICEA) of the University of Naples Federico II has set up a study to shed light on the links between energy consumption and the physical characteristics of urban settlements (Papa et al., 2106). To undertake such elaborations we chose a neighborhood in a densely inhabited area which, both by supplies and location, has high vulnerability levels: a neighborhood in the city of Naples, one of the most densely inhabited metropolitan areas in Europe, within which an urban environment with homogeneous constructional, settlement and morphological characteristics was identified, namely Rione Gemito in the Arenella neighborhood, a complex of 29 buildings, erected between 1946 and 1948, social building, from a project by Marcello Canino and Alfredo Sbriziolo. Conceived to house the homeless from the Second World War, the complex is designed in a cross-shape where the buildings are arranged lengthwise along two rows either side of a broad tree-lined avenue (via Altamura), according to a late 19th-century pattern of an ordered residential neighborhood (La Gala, 2006).

The building complex was particularly suitable for being studied not only because of the substantial constructional and functional homogeneity of its buildings but also for the possibility of finding information on the levels of risk to which the area is potentially subject. Using in-depth analysis of the documents and studies conducted in this context, a picture was outlined of the possible vulnerability level of the area to several natural risks, namely:

- risks connected to climate change, such as flooding and water bombs: the expected performance of the infrastructure network for rainwater treatment is low and could be insufficient to withstand huge flows, due to exceptional precipitation, far higher than those actually planned for. In particular, the 2000 report on the state of the Naples subsoil, the fruit of a survey conducted by a technical committee appointed by the Municipality of Naples, which analyzes, amongst other things, the state of the Municipal water treatment network, stresses that the sewage of the whole complex of buildings in Rione Gemito ends up in the channel "Arena S. Antonio" (fig. 9), described by the same report as being "insufficient in many stretches, [...] both with regard to flood discharges with a thirty-year return period, and with respect to those with a two-year return period" (Comitato Tecnico, Comune di Napoli, 2000). It appears evident that in such conditions, the system of rainwater disposal will soon no longer be able to withstand increasingly intense water discharges due to phenomena linked to climate change, highlighted in the previous sections;
- seismic risk: a recent study by the Department of Structures for Engineering and Architecture (DIST, ex DAPS) of the University of Naples Federico II, for the purpose of defining criteria for the static control of buildings in reinforced concrete built in Naples in the years 1950-1970, showed the poor static conditions of several buildings in Rione Gemito (tab. 2). In such conditions it may be hypothesized that the performance response of the structures could also be compromised in the presence of low-magnitude seismic events, compatible with the levels expected in the area falling within seismic zone 2, i.e. "zone with average seismic hazard where fairly strong earthquakes may occur" (Decree of the President of the Council of Ministers no. 3274/2003, amended by the Resolution of the Campania Regional Government no. 5447 of 7.11.2002).

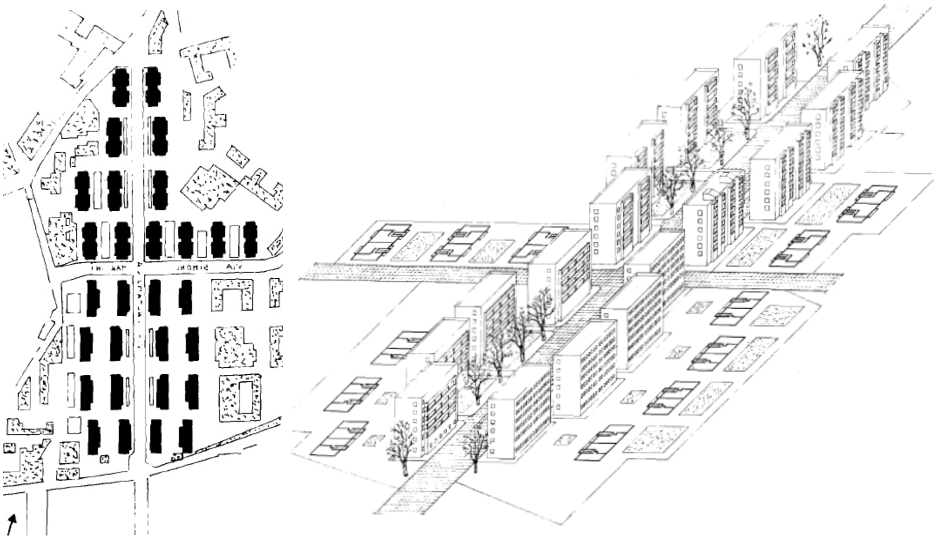


Fig. 4 and 5 Rione Gemito, plan and prospect

Fig. 6 One of the buildings of Rione Gemito

Figs. 7 and 8 Rione Gemito, plan. From: Sergio Stenti, Napoli moderna, città e case popolari 1868-1980, CLEAN edizioni, 1993

Fig. 9 Plan of the Rione Gemito sewage network

ADDRESS	DAMAGE	DESCRIPTION	MATERIAL
Via Altamura 12 is 19	Plaster detached	Plaster detached on facade	RC
Via Altamura 12 is 19	Plaster detached	Plaster hazardous on outer facade	RC
Via Altamura 1 is 5	Ceiling damaged	Partial collapse of SAP ceiling, detachment	RC
Via Altamura 2 is 28	Ceiling damaged	Damage to SAP ceiling	RC
Via Altamura 2 is 25 sc. H-G	Ceiling damaged	Damage to ceilings	RC
Via Altamura 2 is 24 sc. E	Ceiling damaged	Damage to roofing cover	RC
Via Altamura 14 is 20 scala T	Ceiling damaged	Damage to ceiling	RC
Via San Giacomo dei Capri 21, Sc A	Ceiling damaged	Damage to roofing cover	RC
Via Altamura 2 is 22	Ceilings and pillars damaged	Damage to ceilings, staircase, pillars, cellars	RC
Via Altamura 2 is 27-29	Pillar damaged	Detachment of iron covering	RC

Tab. 2 Classification of damage recorded in the buildings in Via Altamura (Rione Gemito).

- volcanic risk: the Arenella neighborhood falls within the Yellow Zone according to the 2015 Amendment of the National Emergency Planning for Volcanic Risk in the Campi Flegrei and comes within the curve of 10 and 5 cm of volcanic ash accumulation according to the Forecast Scenarios of Possible Eruptions of Vesuvius (INGV, 2012) (fig. 10). In such scenarios, the presence of damage to bearing structures emerging from the DIST study could cause partial or total collapses of roofing, besides causing damage to civil structures, hydraulic systems, the system of rainwater drainage, telecommunications and the electricity network. Moreover, there is the high probability of eruptive events generating other hazardous phenomena, thereby increasing risk factors: we refer, for example, to earthquakes that usually precede and accompany eruptive activity, to "*deposition due to the fallout of dissolved pyroclastites close to steeply sloping areas, to flooding caused not only by intense rainfall but also by the reduction in soil permeability due to the deposit of fine ash emitted during the eruption"* (INGV, 2012).

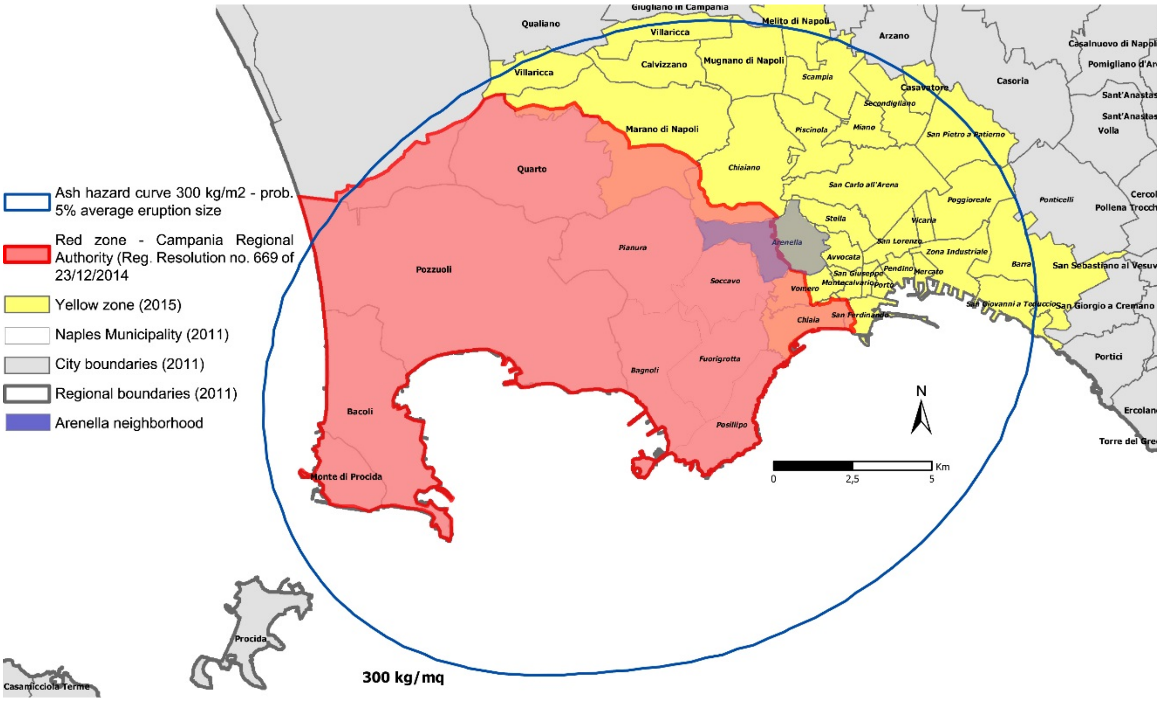


Fig. 10 Campi Flegrei, Map showing the boundary of the "yellow zone"

Analysis of the possible risks to which the study area is potentially exposed leads to identifying measures that require the unified control and management of the project choices to be taken. It is therefore important to stress that one of the fundamental aspects for interventions to be effectively and coherently undertaken is that the area to undergo changes is owned by - or under the control of - a single owner (or group of owners), developers or a public authority. Indeed, only in such circumstance is it possible to carry out an organic project, in which conflict and personal interests are kept to a minimum, and where economic resources may be identified unequivocally. Precisely after such consideration, the choice of case study fell on Rione Gemito, a social housing complex owned by the Istituto Autonomo di Case Popolari of the Naples Provincial Authority. These conditions open the way to a prospect of greater project feasibility, given that the area concerned may undergo public interventions, thereby increasing the property value to the benefit of the State.

3.1 STUDY OF THE RELATIONSHIPS BETWEEN ENERGY CONSUMPTION AND PHYSICAL URBAN CHARACTERICS: ANALYTICAL PROCEDURE

In light of the above considerations, with a view to identifying integrated intervention proposals to satisfy different requirements, energy consumption of the area in question needs to be analyzed so as to propose solutions which can pursue the set objectives most effectively. In this context an analytical procedure is proposed, set up by the TeMALab laboratory of the Department of Civil, Architectural and Environmental Engineering (DICEA) of the University of Naples Federico II, in order to investigate the possible implications on energy consumption of specific characteristics of urban areas. The working group carried out a study on the whole neighborhood of Arenella to determine, on the one hand, the possible physical factors which combine to increase or decrease consumption (tab. 4) and, on the other, whether for areas with similar settlement characteristics lower or higher consumption may be achieved than in the whole neighborhood. The analytical procedure in this study was structured in various phases:

- data retrieval and choice of the statistical unit of reference. The set of information extracted primarily from ISTAT sources or from calculations using data supplied by local authorities was arranged and organized with respect to the statistical unit of reference identified in the census block;
- georeferencing of information relative to the physical characteristics of the buildings and total and mean consumption of electrical energy and gas by census block;
- choice of environmental variables. Following the arrangement of the information gathered, variables that might allow a better understanding of the area's physical characteristics were calculated. Of these, 29 were then selected relative to the neighborhood's physical, functional, constructional and social characteristics;

	VARIABLES	DESCRIPTION
1	Sup_SEZ_ha	Surface area of the 2011 census block [ha]
2	Sup_cop_edf_res	Covered surface area of residential buildings [ha]
3	Rapp_sup_cop_edf_res_Sup_SEZ	Ratio of residential building covered area by census block
4	Vol_tot_edf_res	Residential building volume total [m3]
5	Dens_Vol_tot_edf_res	Residential building volume total/land surface area
6	Alt_med_edf_res	Mean height of residential buildings [m]
7	Media_N_piani	Mean no. of stories per residential buildings
8	N_abtz	Number of dwelling units
9	Dens_N_stanz	Number of dwelling units in land area/Land surface area
10	N_stanz	Number of rooms
11	Dens_N_stanz	Number of rooms in land area/Land surface area
12	SupAbtzSez	Total surface area of dwellings as at 2001 [ha]
13	Ind_util_res	Land use index for residential buildings (SUL dwellings, Land area)

Tab 4 Part of the list of area variables

- construction of a matrix in which the rows are represented by census blocks and the columns by area variables and energy consumption;
- multivariate statistical PCA analysis (Principal Component Analysis) to identify, from a large number of variables, a small number of so-called latent variables;

- identification of five principal components able to explain about 75% of total variables. These components are represented in the form of axes which express a synthetic index of area variables (tab. 5);
- correlation of physical characteristics with energy consumption through projection of the latter upon the principal components, in their quality as illustrative variables;
- statistical analysis of groups (clustering). The individual census blocks are grouped into five clusters on the basis of homogeneity of values of the associated variables (physical and consumption), with respect to the mean values found in the whole neighborhood;
- identification of the energy consumption component within each group and understanding of its relation to the components of physical characteristics;
- representation of clusters in the area and data interpretation (fig. 11).

The analytical procedure proposed was reiterated after the first results, allowing for different area contexts. Below we illustrate the first results and subsequent calculations which were required with a view to in-depth investigation of the area in question.

VARIABLES	AXIS 1	AXIS 2	AXIS 3	AXIS 4	AXIS 5
Vol_tot_edf_res	0.25	-0.92	0.10	-0.23	-0.05
SupOccRes	0.29	-0.91	0.07	-0.27	-0.02
SupAbtzSez	0.31	-0.90	0.08	-0.28	-0.03
N_stanz	0.31	-0.90	0.07	-0.28	-0.03
N_abitz	0.30	-0.90	0.07	-0.28	-0.04
P2011	0.26	-0.88	0.08	-0.28	-0.01
MediaDiComptz	0.29	-0.37	-0.03	0.50	-0.41
Sup_SEZ_ha	-0.33	-0.29	0.62	0.14	0.03
IGnR	-0.40	-0.22	0.64	0.17	-0.03
GnPR_ok	-0.55	-0.15	0.64	0.20	0.05
Ind_copert	0.69	-0.13	-0.28	0.33	-0.12
raggio di inf# sup# verde	-0.43	-0.11	0.65	0.22	0.13

Tab 5 Part of the tables of PCA referring to the identification of the main axes

3.2 FIRST RESULTS

The objective of the analysis undertaken was to ascertain whether and to what extent energy consumption was determined by area characteristics. From preliminary analysis of the matrix of correlations between physical variables and energy consumption there emerge no direct correlations. By contrast, principal component analysis restores a fairly coherent picture of the area characteristics, defined by “axes” or principal components:

- Axis 1: The first axis presents a variance of 30.26%. Hence it is the axis which supplies the most information on the area. The variables with a significant correlation concern the mean height of residential buildings, density, property value and glass surfaces. This axis may thus be interpreted as describing local building density. It does not present significant correlations with consumption.
- Axis 2: The second axis presents a variance of 23.80% and refers to population variables, number of dwellings and rooms and the surface area of dwellings in the census blocks. It is an axis which may be defined approximately as that which best quantifies the population and dwellings.

- Axis 3: The third axis shows a variance of 9.83% and refers to the variable of green surface area per census block and the surface area in hectares of the block. It may be maintained that this axis yields the quantity of the green surface area vs. the area of the census block.
- Axis 4: The fourth axis shows a variance of 6.71% and presents only one statistically significant value relative to the variable of the mean compactness ratio of residential buildings, understood as the ratio between the surface area of the building shell and its volume.
- Axis 5: The fifth axis has a variance of 4.17%. It does not present statistically significant values.

In order to understand how the physical characteristics described by the above axes are aggregated and arranged in the area and which of these groups have the highest consumption, the second phase in the study, consisting of cluster analysis, allows identification, with a hierarchical algorithm, of five classes (or clusters) which, under an initial interpretation, are defined as follows:

- Cluster 1: Residential areas with medium building density. This group is characterized by medium-size census blocks, with a medium-low density of residential buildings, a low index of area use for residential buildings and consumption slightly above average.
- Cluster 2: Residential areas with high building density. This group identifies smaller census blocks, with a high cover index, high buildings, higher property value and scarce presence of green areas.
- Cluster 3: Residential areas with a high employment index. Falling within this cluster are very small census blocks, with a very high building density and especially a high employment index for residential buildings. The areas in this cluster have higher property values than cluster 2 and present lower energy consumption.
- Cluster 4: Open spaces and squares. This group identifies census blocks that have no buildings. Thus there are no inhabitants resident there and no residential consumption. However, consumption for public lighting, identified by the index of mean annual consumption per area unit, is much higher than the average for the whole neighborhood.
- Cluster 5: Areas of low building density. These are very large census blocks, but with few scattered buildings. They have a high density of green areas and very high energy consumption on average.

From the depiction of the distribution of clusters in figure 11, the study area of Rione Gemito can be identified, divided into four distinct census blocks. Against the homogeneity of constructional and settlement characteristics of the complex of buildings, cluster analysis yielded some seemingly inconsistent results: 2 of 4 census blocks fall in cluster 1 and the other 2 in cluster 2 (tab. 6).

BLOCK	CLUSTER
1	1
2	2
3	1
4	2

Tab 6 Distribution of census blocks by cluster

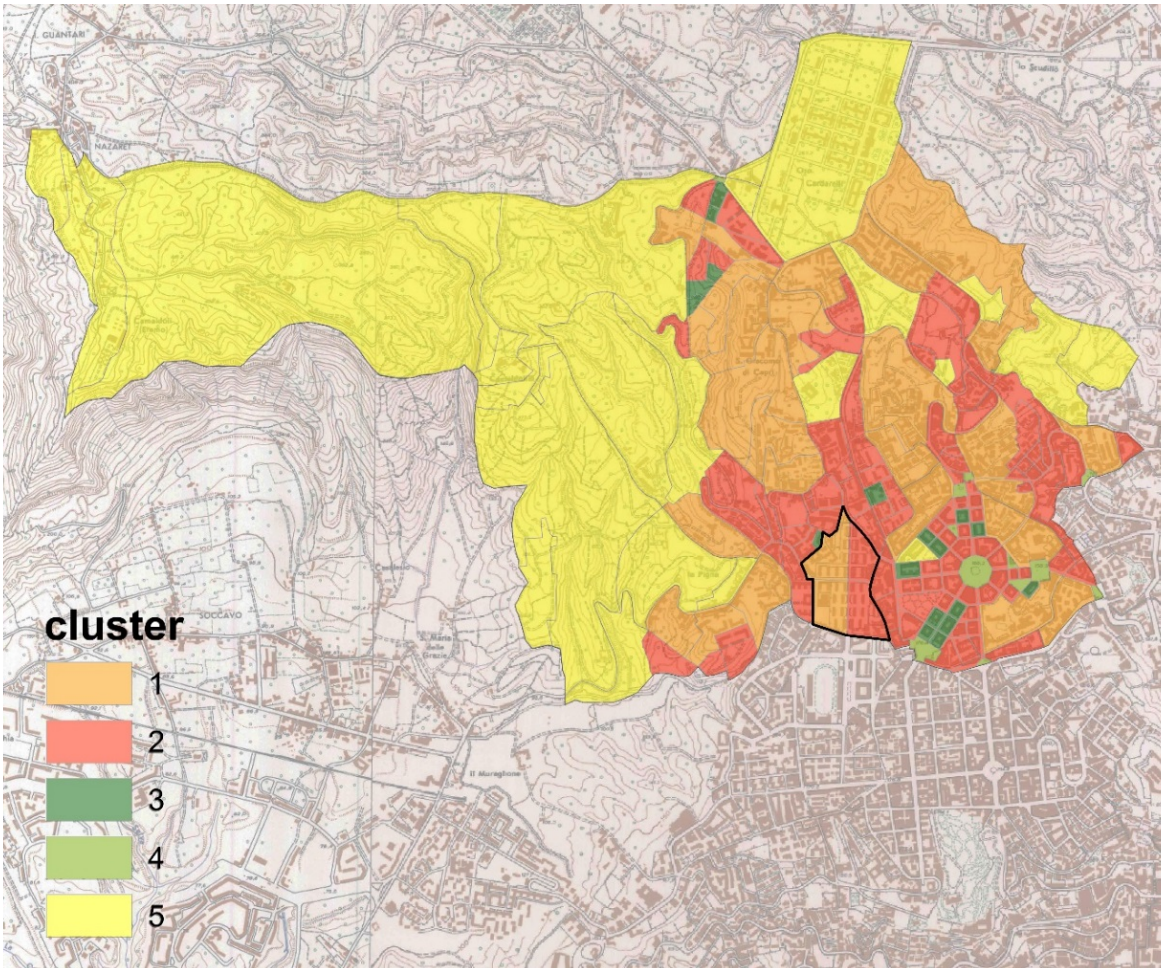


Fig. 11 Representation of cluster analysis in the Arenella neighborhood, Naples

3.3 NEW AREA BOUNDARIES AND DATA REPROCESSING

The values emerging from cluster analysis show dishomogeneity of data for the four census blocks in which Rione Gemito falls. This result highlighted a fundamental aspect: the four census blocks not only comprise the buildings of the Gemito complex, but also a non-negligible number of other buildings differing in shape, number of stories and construction characteristics. This was why we chose to subdivide each of the four census blocks, distinguishing the part of the area containing the complex in question from that occupied by other buildings, thereby obtaining eight new census blocks. These blocks were numbered progressively (fig. 12) which allowed two groups to be distinguished:

- group of “Rione Gemito”: 2,3,6,7;
- group of “buildings outside Rione Gemito”: 1,4,5,8.

PCA and cluster analysis were then performed once again, this time referring to the eight new census sub-blocks obtained by the subdivision of the original blocks, so as to be able to determine energy consumption values in a context characterized by functional, spatial and territorial homogeneity.

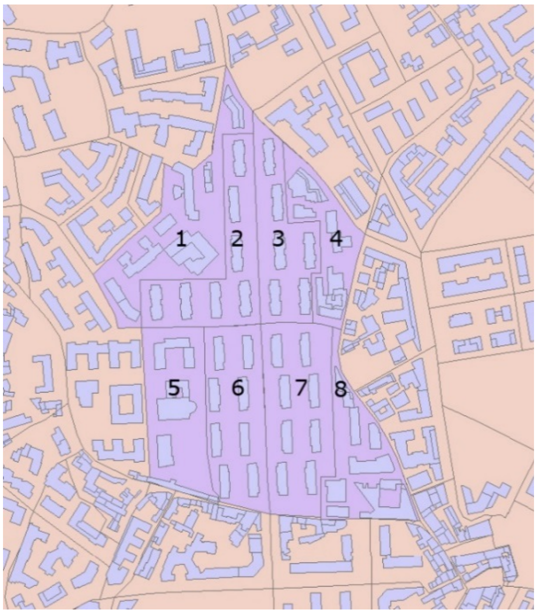


Fig. 12 The 8 subsections of Rione Gemito

3.4 TESTING AND COMPARISON OF RESULTS

Calculations carried out on eight census blocks showed, as hypothesized, a homogeneity of values regarding the individuals of Rione Gemito which all belong to cluster 3. By contrast, the sub-blocks outside Rione Gemito partly fall in cluster 3 and partly in cluster 5 (tab. 7).

In order to understand the results of the analyses carried out, we sought to interpret the distribution by identifying some variables deemed significant for the location of each sub-block in a given cluster.

It should be stressed that the main factors in determining clusters, thanks to which it was possible to envision specific intervention measures, were defined through synthetic interpretation of the results obtained by PCA and cluster analysis for the whole sample of individuals comprising the census blocks of Rione Gemito. In this context, so as to limit the field of interpretation some additional statistical analysis would be necessary, developing the work phases and examining the parameters more rigorously.

BLOCK	CLUSTER	CONTEXT
1	3	External
2	3	Rione Gemito
3	3	Rione Gemito
4	3	External
5	5	External
6	3	Rione Gemito
7	3	Rione Gemito
8	5	External

Tab 7 Distribution of census sub-blocks by cluster

Considering primarily the variables which have most weight in defining cluster 3 (that containing Rione Gemito), highlighted in table 8, it is noted a high area use index of occupied residences (*Ind_util_res_occp*= relationship between the area of occupied dwellings and the area of the block), a high density of residential buildings (*Dens_N_EdfRes*= number of residential buildings per surface area), high buildings (*Alt_med_edf_res*= Mean height of residential buildings) and high presence of glass surfaces (*Somma_Sup_vetrate*= Sum of glass surfaces in residential buildings) (tab. 7, data highlighted in red). Moreover, the cluster is distinguished by low energy consumption by domestic residential and non-residential unit (highlighted in blue).

CLASSE 3 / 5 (Poids = 18.00 Effectif = 18)						
Variables caractéristiques	Moyenne dans la classe	Moyenne générale	Ecart-type dans la classe	Ecart-type général	Valeur-Test	Probabilité
Ind util res occp	1,179	0,239	0,339	0,365	11,48	0,000
Dens Vol tot edf res	67712,900	14144,500	21577,900	21132,700	11,31	0,000
Dens N EdfRes	4,682	1,086	2,464	1,619	9,91	0,000
Dens N EdfTot	4,682	1,102	2,464	1,616	9,88	0,000
Somma Sup vetrate	752,877	290,987	229,331	236,780	8,70	0,000
Dens N EdfResCalS	2,922	0,692	2,406	1,212	8,21	0,000
Dens N EdfResMurP	1,600	0,280	2,091	0,871	6,76	0,000
Alt med edf res	26,345	17,672	4,948	9,203	4,20	0,000
Media N Piani	8,778	5,947	1,635	3,050	4,14	0,000
h media tot	24,678	17,582	5,943	7,946	3,98	0,000
Dens	9,056	6,477	2,168	3,756	3,06	0,001
VAL IMM	4727,780	3776,270	341,249	1452,710	2,92	0,002
D Pop	434,616	298,754	200,300	238,941	2,54	0,006
Somma di Consumo UDR	14839,100	40701,100	7374,720	46662,500	-2,47	0,007
Vol tot edf res	31093,200	80927,100	12031,200	89106,900	-2,49	0,006
Somma di Consumo UDNR1	7229,830	24352,800	5442,200	29213,100	-2,61	0,004

Tab 8 Determinant variables in cluster 3

Representation of the results of the analyses using a Cartesian system in which the x axes and y axes are respectively axes 1 and 2 helps appreciate the distribution of the eight sub-blocks of Rione Gemito along a common axis (fig. 13).

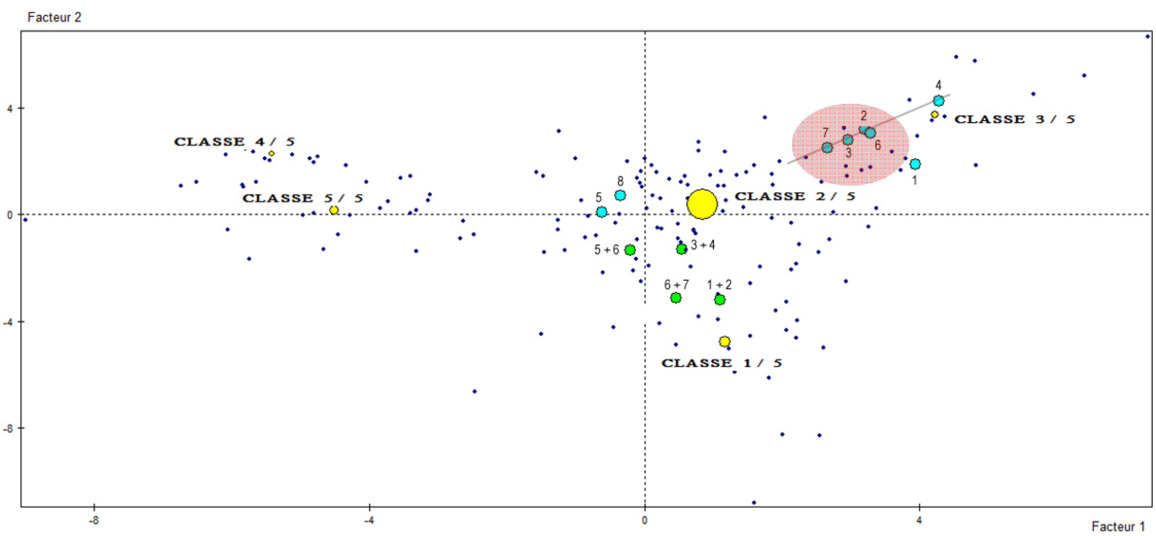


Fig. 13 Distribution of the blocks and sub-blocks relative to Axes 1 and 2

In figure 13 the green circles represent the blocks comprising Rione Gemito and several external buildings, the blue circles represent the sub-blocks obtained following the division, while the group highlighted in red represents the census sub-blocks which comprises only Rione Gemito. What appears evident from the figure is an almost overlap of sub-blocks 2 and 6 and an alignment of sub-blocks 2,3,6, 4 and 7. Further, points 2, 3, 6 and 7, which include Rione Gemito (highlighted in red) are very close to one another. This result may be explained by examining the variables which best characterize cluster 3 (tab. 8 highlighted in red): for the single sub-blocks belonging to Rione Gemito, there emerge very close values as regards the mean height of the buildings (residential and non-residential), total glass surface areas and property density. The values confirm the hypothesis of a close relationship between homogeneousness of "physical" parameters and energy consumption, in which height, glass surface areas and building density represent significant aspects.

	Sup_SEZ_ha	Vol_tot_edf_res	Dens_Vol_tot_edf_res	Alt_med_edf_res	Media_N_Piani	N_abitz	N_stanz	SupAbtzSez	SupOccRes	Ind_util_res_occp
1	1,527743	120198,848	78677,40058	22,968462	7,615385	222	875	1,7613	1,722671566	1,127592511
2	1,19497	63663,93038	53276,59303	21,374286	7	168	840	1,6128	1,577428434	1,320056934
3	1,018886	54964,42592	53945,60914	21,766667	7	144	720	1,3824	1,351895494	1,326836853
4	0,79225	67458,92354	85148,53081	21,031818	7	126	361	0,7702	0,753204506	0,950715691
5	1,157666	39664,97064	34262,87949	13,135556	4,555556	202	885	1,7641	1,683604654	1,454309494
6	1,22411	62032,50429	50675,59638	21,115	7	192	960	1,8432	1,759095346	1,437040254
7	1,464064	63775,73122	43560,75364	21,385	7	192	960	1,8432	1,790727478	1,223121037
8	1,009956	56099,12522	55546,10817	12,946429	4,214286	79	125	0,1766	0,171572522	0,169881185

Dens_N_EdfTot	Dens_N_EdfRes	Dens_N_EdfNRes	Dens_N_EdfResMurP	Dens_N_EdfResCalS	Somma_Sup_vetrate	MediaDiComptz	GnPR_ok	Dens
5,236482838	5,236482838	0	0,65456035	4,581922483	155,598834	0,292312042	0,057225	7,867740058
5,857887646	5,857887646	0	5,85788765	0	204,54	0,293683997	0	5,327659303
5,888784417	5,888784417	0	0,98146407	4,907320348	175,32	0,29873286	0	5,394560914
7,573366993	7,573366993	0	0,00000000	7,573366993	131,896817	0,363558101	0	8,514853081
2,591421014	1,72761401	0,863807005	0,00000000	2,591421014	42,44197	0,254161683	0,174467	3,426287949
6,535360384	6,535360384	0	1,63384010	4,901520288	226,8	0,29959786	0	5,067559638
5,464242	5,464242	0	4,09818150	1,3660605	200,8	0,296283361	0	4,356075364
8,911279303	5,940852869	2,970426434	0,00000000	8,911279303	19,290917	0,337757979	0	5,554610817

h_media_tot	Ind_copert	raggio di inf# sup# verde	IGnR	Asp_ratio	P2011	D_Pop [ab/ha]	Lumen_sup [lm/ha]	cons_sup[Mwh/Kmq]	VAL_IMM	d_Pop_1
22,968462	0,316362828	6011,60419	0,39350	2,259665	673	440,7809429	36655,37986	202,91371	4300	146
21,374286	0,249264413	2008,549299	0,16808	1,089884	510	426,4542206	130547,2104	736,4201612	4300	111
21,766667	0,247887156	0	0	1,590446	292	286,8492321	160960,1074	745,9126929	4300	147
21,031818	0,383831973	0	0	1,818532	256	322,7937309	111580,9404	570,5269801	4300	129
13,135556	0,159784558	6872,391727	0,59364	0,848828	396	341,8921816	69622,84459	472,675193	4300	147
21,115	0,239983337	1872,104695	0,15294	0,896366	376	307,3278102	132014,2798	741,7634036	4300	140
21,385	0,20385362	0	0	0,86172	431	294,2222113	94804,59871	501,3442035	4300	213
12,946429	0,426675687	0	0	0,862306	177	175,4926476	24951,58205	124,7579102	4300	88

Tab9Table summarizing values calculated for the eight reference sub-blocks

Another consideration concerns the overlap of points 2 and 6: in this case it is the parameter relative to the radius of influence of the green area which supplies a possible interpretation: from the values of this indicator (highlighted in blue in tab. 8) and the area representation obtained thanks to GIS calculations (fig. 14), the presence of two green areas behind sub-blocks 1-2 and 5-6 appears significant.

In light of the results obtained, it emerges that the presence of greenery affects the behavior of blocks 2 and 6, with reference to "physical" and "energy" parameters, so much as to cause an almost complete overlap of the points in the graph.

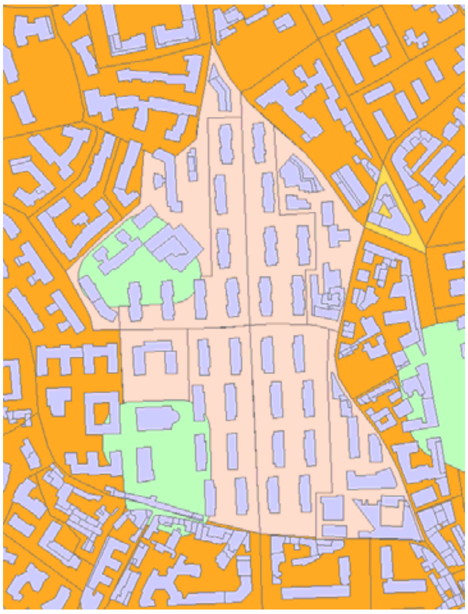


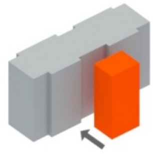
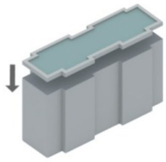
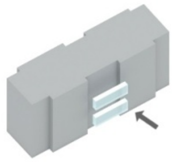
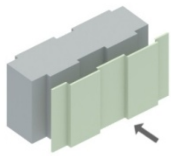
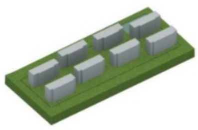
Fig 14 Radius of influence of green areas in Rione Gemito

3.5 INTERVENTION PROPOSALS

Following what emerged from the statistical analysis carried out, it may be suggest that there are some construction, settlement and area characteristics in Rione Gemito which may affect, more than others, determination (hence containment) of consumption. They may be briefly grouped as follows:

- index of land use;
- mean height of residential buildings;
- glass surfaces;
- construction type;
- radius of influence of green areas.

The intervention proposals designed to reduce energy consumption should thus have to take these factors into account so as to improve the overall performance of the area. Moreover, in relation to the points made in the previous sections regarding urban vulnerability, the interventions to be proposed should have to target adaptability to climate change and the reduction in seismic and volcanic risk. The possible interventions which might be hypothesized for Rione Gemito are shown in Table 10. For each of the factors listed measures to adopt were identified and some considerations on their feasibility were formulated. As regards the index of area use, an increase in area occupied by buildings might be hypothesized which, besides having benefits on the reduction of consumption, would also allow value to be created following the realization of extra rooms. However, despite the possible benefits, this intervention was considered inappropriate for Rione Gemito by virtue of the high index of current area use and the complexity of intervening in an urban fabric strongly characterized by strongly marked-out axes. By contrast, interventions on building roofs could be taken into consideration, envisioning operations on raising vertical structures or on foundations, to increase the capacity of the whole system. Depending on the case, various interventions could therefore be envisioned: from insulation of the roofing, to construction of a roof garden or an area of water, to building an additional floor. These interventions are deemed particularly strategic for the potential beneficial effects in various respects: reduction in energy consumption, containment of the effects of climate change, reduction in vulnerability to volcanic and seismic risk, improvement in the perceived quality of the context and creation of economic value.

FACTORS	INTERVENTION TYPE	OBJECTIVE	APPLICATION	INTERVENTION FEASIBILITY
Index of area use	Increase in building area	Reduction in energy consumption per m^2, economic benefits		NO
Mean height of residential buildings	Creation of an extra story/cover rebuilding	Reduction in energy consumption per m^2, improvement in cover resistance in the event of ashfall, mitigation of climate change effects		YES
Glass surfaces	Building of solar greenhouses /suitably screened winter gardens, with or without an increase in volume	Reduction in energy consumption per m^2, mitigation of climate change effects, economic benefits		YES
Construction type	Interventions on building shell: insulation/ventilation of facades; creation of outer support structures to increase the building's resistance	Reduction in energy consumption per m^2, mitigation of climate change effects, increase in structural resistance in an earthquake		YES
Radius of influence of green areas	Increase in green areas in the roofing, in the facade and in public urban areas, creating of water collection sites	Reduction in energy consumption per m^2, mitigation of climate change effects, increase in urban quality and appreciation of property value		YES

Tab. 10 – Summary of possible interventions for Rione Gemito

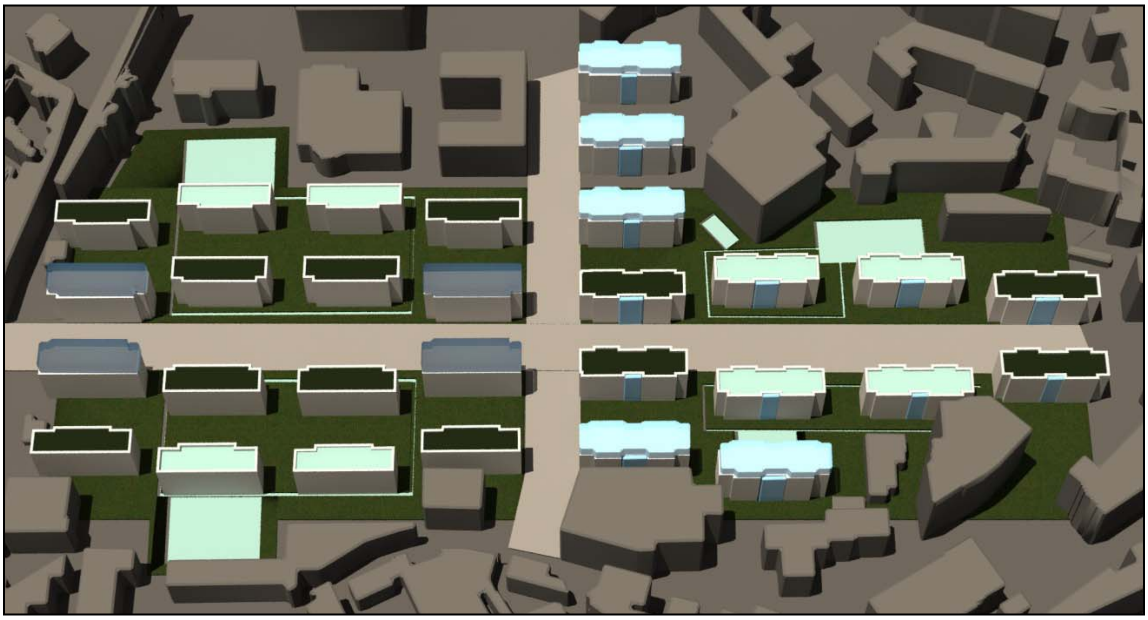


Fig 15 Schematic representation of the combination of interventions proposed in Rione Gemito

As regards the presence of glass surfaces on the facade, a possible intervention comprises south-facing solar greenhouses/winter gardens which, if properly designed, could confer many benefits both in terms of a reduction in consumption and attenuation of sharp changes in temperature. However, it should be borne in mind that in climatic contexts like those in Naples, such interventions may not be necessary, or they may even create negative temperature effects, which is why one needs to evaluate carefully when and in what way measures should be implemented. With reference to the construction type of the buildings, interventions are proposed on vertical closures, given the levels of the transmittance of the building shell and the possible presence of thermal bridges. Such operations may be combined with interventions on elevation structures so as to obtain at the same time interior temperature benefits and improvements in the seismic response of the whole building.

Finally, it is felt that increasing the presence of green areas is the intervention which would confer greater benefits in terms of the environmental quality of the urban contest and an increase in property value in the whole study area. The results obtained by the present study demonstrated the importance of creating larger green areas than the small flower beds to confer microclimatic benefits and reduce energy consumption in the whole area. In addition, we propose the creation small pools and water courses, whose movement may be fed by photovoltaic panels integrated within the urban furniture, so as to mitigate and prevent the heat island effect, function as storage sites on the occasion of abundant rainfall and, at the same time, improve the urban quality of public spaces.

5. FUTURE RESEARCH DEVELOPMENTS

This paper sought to highlight the possibility of identifying integrated strategies to optimize the ever-diminishing supply of resources at the disposal of municipal authorities in order to maximize benefits in terms of reducing energy consumption, reducing urban vulnerability, and improving the quality of the building stock whilst enhancing its value. The intervention proposals were formulated to be grafted onto a theoretical context consisting of the set of recent scientific research developments in very disparate disciplines. This contribution may thus constitute a speculative support to set up a *masterplan* of concrete interventions, within which the times, costs and suitable technologies are established. The attention paid in this article to the importance of tackling the complexity of the issues within a holistic framework underlines the original, disseminating nature of the contribution and opens the way to future testing in greater depth. In this sense, although the calculations yielded some significant results, further statistical exploration would be desirable, setting up a more rigorous methodology, which could make the analytical procedure more scientific. Indeed, the research procedure was carried out through two kinds of analysis: the ACP and Clustering, which provide such valid results in terms of correlations between physical parameters and energy consumption. These two analysis were repeated twice: while the first calculations produced no particularly relevant findings, their reiteration provided some significant results. The interesting datum emerging from the comparison of the two elaborations is that the homogeneity of constructive characteristics of buildings plays a determinant role in the correlations of variables and consumptions: actually, it emerged that the more the buildings are similar in terms of physical parameters, the more the correlations are evident. In this context, it would be worth applying the analytical procedure to a less homogeneous area in terms of construction, settlement type and land area than the neighborhood in question. Such an extension would help validate the proposed methodology. In this context, selecting a sampling area characterized by dishomogeneous buildings, preferably threatened by different risks or of different intensity than those identified in Rione Gemito, may provide interesting insights for a different selection of measures to combine each other.

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IMAGE SOURCES

Fig. 1: Rotterdam Adaptation Plan.
Fig. 2 and 3: Chelseacreak (London). Photo taken by Chiara Lombardi and masterplan.
Fig. 4 and 5: Sergio Stenti, Napoli moderna, città e case popolari 1868-1980, CLEAN edizioni, 1993.
Fig. 6: DICEA archive of the University of Naples Federico II.
Fig. 7 and 8: Sergio Stenti, Napoli moderna, città e case popolari 1868-1980, CLEAN edizioni, 1993.
Fig. 9: Centro Studi PLINIUS, University of Naples Federico II.

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