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Sustainable networks in the rehabilitation of built historic heritage

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The research links the issue of recovery of the small Italian historic towns to the environmental issue, proposing the sustainable rehabilitation as opportunity to carry out a virtuous action in the territory. The redevelopment of minor historic centres that characterize Italy can become an opportunity to start a process of strategic regeneration of the territory, useful to produce a diffuse quality of life without which every action would have difficulty in being effectively successful. The interest for these centres struck by the earthquake of April 6, 2009, offered the opportunity to carry out research that can rediscover the environmental sustainability elements presents, to identify intervention environments and the technological solutions. The research, identified the main issues affecting the minor centres, examines the measures launched by Italian Government to activate reconstruction and energy compliance politicies. The goal is to carry on a redevel-opment involving more towns, in order to create a relation system between the centres, making the energy redevelopment organic and effective. The research applies the proposed methodology on a case study in the Province of L'Aquila: the village of Fontecchio and the territorial networks that is created with the neighboring villages of San Pio di fontecchio and Sant'Eusanio Forconese.

Introduction

At a time of global energy crisis the focus on built recovery appears on the one hand as a true need, on the other hand as a chance to save resources, economics and territorials, preserving the memory and the identity of places.

In this way, the importance of historical buildings recovery and reuse has developed interest regarding the wealth of ancient small towns that represent the historical national and territorial organization that characterize the Italian territory, both for their individual specificity, and more importantly as an overall cohesive system.

For decades, however, these small centres, located mainly along the Apennine ridge, have been affected by depopulation and abandonment conditions due to the loss of economic power and low quality of life resulting from the lack of services (Rolli G.L., 2008).

As is clear from recent studies carried out by Italian public companies such as Legambiente and Confcommercio, and private company like Norman Group, 72% of the more than 8.000 Italian municipalities have fewer than 5.000 inhabitants.

These towns are subject to different kinds of depopulation, for a long time wrongly identified with the term minor for the specificity of their size and the narrowness of their economic power (Secchi, 1984). However, this epithet is inappropriate if you recognize the wealth of architectural and environmental values these centres have protected for generations and the specific character that they represents to the national territory.

In recent decades, renewed interest in the historical villages can be attributed to a variety of factors. First, they are numerous in the area and, therefore, contribute to the diffusion of the problem. Secondly, they are significant for their historical, architectural and environmental values. Finally, there is a need for these mountain areas to recover economic attraction by introducing new housing and forms of tourism (Bonamico S. et al., 1996).

Moreover, in light of the culture of sustainability, the concept of recovery is associated with the ability to perform a virtuous action directed at re-using existing buildings, the limitation of land consumption, revaluing material culture in addition to the introduction of technologies improving energy efficiency in these contexts (Maietti F., 2008).

The situation after the 2009 earthquake and adopted policies

The ministerial decrees (Dl n.3 16/04/2009 and followings), in the initial months following post-earthquake, defined a seismic crater the area of land extending over three provinces, L'Aquila, Teramo and Pescara, for a total of 57 municipalities distributed differently among them.

The seismic crater represents a small portion of land, approximately 3000 square kilometers, the majority being mostly mountain communities, and involves a population of less than 200.000 inhabitants (Fig. 1).

In an already difficult situation, the earthquake of April 2009 struck the Abruzzo Region, aggravating the state of deterioration and abandonment in which the centres have been for decades and making inevitable changes in territorial and social organization of the settlements.

Figure 1. The seismic crater in Abruzzo Region (Design by Marchionni C.).

The recovery of the seismic crater has been slowed down by excessive bureaucracy with a succession of 143 decrees of the Delegate Commissioner for Reconstruction and 77 decree of the President of the Council of Ministers. Among these, the Abruzzo Decree n. 39.2009, then converted into the Law 77/2009 introduced the Reconstruction Plans (PdR) as a means to ensure the socio-economic recovery of the area, redevelop the town, facilitate the return of people to the recovered homes (Art 14, comma 5).

However, there is a lack of any correlations with other municipalities, as well as any reference to the introduction of incentivizing factors in energy efficiency and sustainability as a programmatic assessment of the most urgent interventions is absent.

This regulatory gap was partially filled three years later when, with the end of the emergency phase sanctioned in the article 67 bis of the Law 134/2012. Integrated programs are introduced in place of the reconstruction plans, in cases where unitary interventions are needed.

Furthermore, the range of targets to be achieved is extended by introducing among them the oblectives of obtaining «a high level of quality in terms of livability, health and safety as well as environmental and energy sustainability of urban fabric and use of modern construction materials and advanced building technologies, also to ensure the seismic improvement and energy savings, and the reorganization of infrastructure networks» (as described at the Article 67 quater).

There are no references to any guideline that clarifies the possible action mode.

As regard energy efficiency incentivizing policies, we report the subscription of all 305 Abruzzo municipalities to the Covenant of Mayors, the only case in the Europe, symbol of the Region's hope for rebirth and to start anew. This pact was founded on an initiative of the European Commission in 2008, following the adoption of the European Climate and Energy Package, to actively involve local governments in the strategy for energy and environmental sustainability.

The Covenant, in fact, is committing local governments to reduce CO_2 emissions by more than 20% of CO_2 by 2020 through the energy efficiency implementation measures. Supporting this initiative constrained municipalities to submit, within one year after the signing, the Action Plan for Sustainable Energy (SEAP), an operational tool to implement energy policies in the area. The plan contains also the BEI (Base Emission Inventory) concerning public and private transports, tertiary facilities and residential buildings energy consumption. Possible intervention are identified and described while a series of scenarios are hypothesized, with the intent of identifying the most effective combination and to minimizing potential investments (Bertoldi P. et al, 2010).

However, some methodological shortcomings are identified relative to the absence of any reference to the specific context of investigation. In the case of minor centres, there is no attention given to the question of compatibility of the proposed interventions and to historical and environmental value of this context (De Berardinis et al, 2014).

Moreover, there are no allusions to the economic impact of the scenarios considered most adept in the territory, a matter not to be ignored considering the delicate economic situation.

Starting from the identified weaknesses, the objective of this research is, therefore, to use in a compatible way the technology in the service of a truly sustainable reconstruction by providing an operational methodology applicable in important and economically weak contexts.

Therefore, the earthquake must not be considered only as an aggravating and harmful factor: the pretext of the earthquake provides an opportunity to revitalize the area with the possibility of reconstruction, where possible and reasonable, taking advantage of technological advancements to adapt comfort levels to those of today (Marchionni, De Berardinis, 2014).

Towards a sustainable redevelopment

The recovery of the built heritage and the values of material culture must act within a framework of sustainable development at a local and supra-local scale, in order to have a chance to succeed.

Knowledge plays a key role to get going the enhancement of cultures, of real estates, of anthropic areas, with a wide range of approaches to the different scales involving hybridization of cultural resources and regenerative technologies.

The sustainable recovery of the minor building is an unavoidable challenge, to be tackled only in a dimension of network between the involved actors. So that the housing problem is an element of social integration and, at the same time, promotes the protection of the territory, the environment and human health, with significant impact on the local economy

This approach involves, however, a different way of understanding the project, a new way of being regarding the problems, overcoming the reduction of reality to technical rigidity.

The goal of environmental sustainability, in fact, «is unattainable without an integrated, morphological and at the same time relational version at the same time of historic centre. There is an interconnection between the physical historic centre, of buildings, squares and streets, and the immaterial one, of values, identity, organization, imagination. The historic centre is not a machine, but an ecosystem. (...) Notwithstanding the importance of the protection of architectural and cultural heritage of historic centre, you cannot fail to mention that there is an objective of adjustment to be pursued in response to the change of the functions performed by the same, in order to move with the times» (Pilati L. et al, 2010).

The reconstruction, therefore, must not only materially provide a roof, but rather, it must generate counter measures to stop the abandonment. Furthermore, totally rehabilitate the historic centres and their economic and social relations.

In order to make this possible, it is essential to implement technologically advanced interventions that, though ensuring high levels of performance, involve considerably lower operating expenses.

The preconditions in order to develop an efficient methodology for the sustainable rehabilitations of villages were based on the following considerations: the historic minor centre is a complex reality, which cannot be separated from its environment. In fact, widening the investigation field we understand the possibility of introducing more effective and less invasive interventions on the consolidated building fabric, always respecting the territory.

We move from the building problem to the problem of historical centre, to that of a set of smaller towns interacting in the area, linked by a common rehabilitation strategy (Briatore S., 2011).

At the base of proposed methodology is the goal of operating on multiple factors identifying the specificity and the favorable characteristics of an area of land which includes more villages.

The aim is to trigger a double process: on one hand the resources sharing, both the exploitation of energy sources and the re-use of an abandoned heritage building.

On the other hand the rediscovery of the potentiality of the territory: routes and architectural and environment peculiarities exploitation, with development of productive, residential and tourist activities. The set of interventions will make the redevelopment efficient and justified.

The proposal is to create smart minor centres by strengthening networks to transfering people, informations and energy, and introducing innovative and compatible solutions.

Technological intervention, therefore, makes sense only if it helps to bring back the population in the centres, ensuring comfort conditions and production facilities connections (Marchionni, De Berardinis, 2014).

Operational methodology development

The preconditions for the development of an effective methodology for the sustainable recovery of minor historical centres are based on a in-depth phase of knowledge of the investigation context, which allows you to justify and validate the choice of an intervention aimed at “active conservation and controlled transformation” (Zordan et al., 2002) of centres.

Accepting a controlled transformation as an operational tool allows on the one hand the technological and functional upgrading of building, on the other hand the preservation of historical, formal and figurative characters.

Therefore it is proposed a compatible process of recovery of the villages affected by the earthquake, providing an operational methodology which, adapted to the individual case through the design phase, allows the adaptation of performance indices of historic centres to needs of contemporary users. This makes attractive an architecture today disconnected from economic circuits, the only ones able to allow its survival.

The developed methodology developed consists of three main steps:

– The meta-phase project:

after identifying the sustainable territories, it was decided to focus the attention on open spaces and energy networks, areas less investigated but that can offer significant performance improvements. The first are classified according to their morphological, functional and, especially, environmental aspects, through bioclimatic analysis (sunshine, ventilation) and biophysical (analysis of soil, water and vegetation) (Sala 2001).

The climatic analysis, drafted after 3D reconstruction of the villages and altitude profile, and the further use of the software Ecotect, allowed us to identify the climate behavior of the areas of interest during the main hours of the winter and summer solstices.

After performing the simulations the critical situation that characterize the open spaces are highlighted such as the humidity and low light conditions of those small space located between the dense urban fabric, the persistent sunlight conditions and the insufficient ventilation for the spaces of larger dimensions located on the margin of settlement or in correspondence with collapsed buildings.

On the other hand the biophysical analysis was carried out classifying the types of grounds present in the villages from the point of view of the ground declivity, the surface and the presence of vegetation, identifying the areas where there is residual moisture.

Regarding the energy grids, the in situ reconnaissance and research in the municipalities, although limited, has allowed to highlight a difficult situation characterized by lack of services and strong deterioration of these networks due to the lack of maintenance and modern renovation.

The first analysis, therefore, have been overlapping with those of the main energy grids present (electricity, water, gas, sewer), to highlight the critical operating situation and the lack of exercise management, as well as very high levels of executive and figurative incompatibility with the context (Pazzaglini M., 2004).

– The development of design scenarios:

is related primarily to technological scenario, which intervenes to solve critical situation listed above using different and complementary solutions.

This, however, must inevitably be supported by the functional scenario and that related to sustainable mobility, in order to make the intervention of reuse attractive to the new user and long-lasting.

The different levels of analysis, made in system with the main features of built, allowed to divide the village into homogeneous areas of intervention for critical conditions and strong points, environmental and functional, where to locate site specific where intervene that can become real energy islands, as well as urban places.

For each zones, as a synthesis of the complex process of knowledge has been possible to propose a design strategy characterized by macro-interventions in relation of the entire village, and micro interventions within the sector.

These include those that promote rational use of energy, fulfillment of environmental comfort, efficiency of energy networks and exploitation of renewable energy sources.

Of the latter, considering the sensitivity of the investigation area, we evaluate the insertion both in on-grid and off-grid modality (Marchionni et al, 2014).

In order to improve environmental (termo-igrometric, light-optical, acoustic) comfort (Olgway V., 1963), for example, a set of congruent solutions is proposed such as the use of vegetation or water as refrigerant systems, the inclusion of green area or the strengthening of trees as screening elements or windbreaks. Additionally these solutioned include the inclusion of transparent and translucent roofs to reduce ground moisture, the introduction of mirrors and reflective walls to increase the levels of illumination of the small streets, etc. (Dessì, 2007).

In the margin spaces or more open areas the inclusion of renewable energy sources is proposed. We study the characteristics of the area to understand the compatibility of other systems (photovoltaic, mini-wind turbine, biomass, mini-water and geothermal energy).

Even in the case of energy networks a number of technological solutions have been classified, that vary from the introduction of ex novo tunnels allowing the passage of most of underground services, to introduction of district heating, to intelligent lighting systems equipped by low energy consumption systems, to improvement of management systems, etc.

Identifying compliant solutions, through the subsequent case-by-case application is verifies which are compatible with the specific case study, because they exceed a complex compatibility process (environmental, technological, functional and economic), whose research provides the parameters evaluation.

Sustainable minor centres in network: identification of a case study

The described methodological phases have been applied on a representative case study, identified through the first level of knowledge described above. This is the network, understood as a system of relations, consituted by the minor centres of Fontecchio, with its suburb of San Pio, and Sant'Eusanio Forconese (Fig. 2).

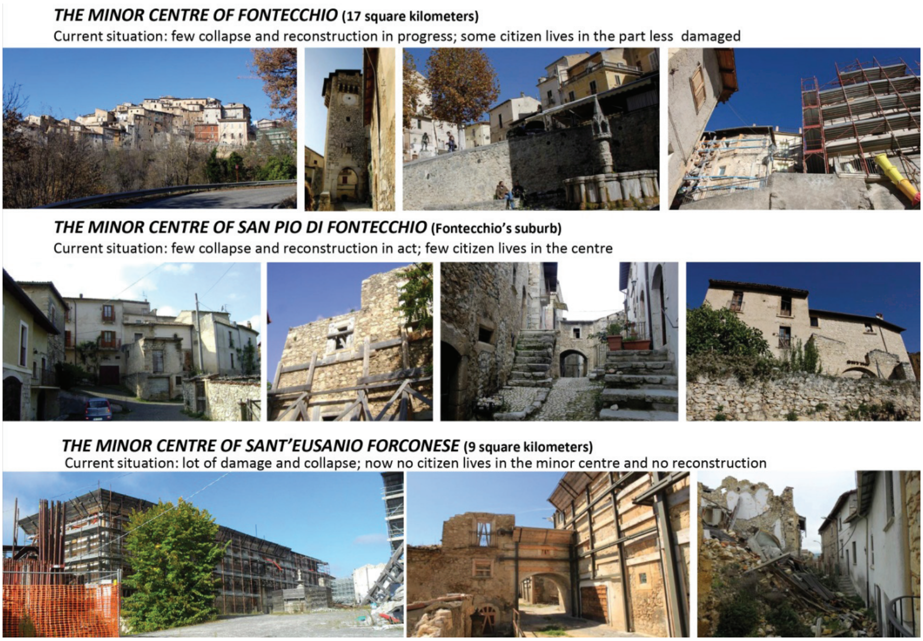

Figure 2. Identification of the case study (Design by Marchionni C.).

The territory of Fontecchio is part of the Montana Sirentina community and the Regional Sirente Park, and covers a total area of approximately 17 square kilometers over the River Aterno. The municipality includes four different settlements: the minor centre of Fontecchio and its suburb of San Pio, Pagliare, a temporary village characterized by simple and small scattered houses, and the system consisting of four Convents.

Fontecchio, historic fortified centre well-conceived in the defensive aspect, expanded several times to contain the ever-increasing population, the village has a typical military and feudal structure, sign of the fact that it focused the main economic, trade and handcrafted activities of the area. Its dense and compact urban fabric developed following the altitude profile as it is located on a sloping land and in the southern part is characterized by tall wall-houses overlooking the surrounding valley.

On the contrary, the village of San Pio, located north of Fontecchio, develops itself on a flat ground and has no real defense structures: it is characterized, however, by having great bricked property formed by the master's palace, stables, farmers' accommodations, barns, utility room for the tools and any other space or structure necessary for the care of the fields, all to testify the agricultural function of the settlement (Paolini G., 2003).

The centre of Sant'Eusanio Forconese, however, has risen in correspondence with a flat territory situated about 594 meters above sea level in the Vestina valley, between the Fossa River and the Averno River, on a small hill. The territory also includes the suburb of Casentino and covers a total area of 9 square kilometers, but the real inhabited town of Sant'Eusanio has an area of only 3 square kilometers (Barbato, Del Bufalo, 1978). It has a oval shape and it has been developed around the piazza and the basilica by narrow streets that reconnect to the distant external ring; the urban fabric is rather compact in the eastern zone of the village, sparser in the western zone, consists by numerous construction aggregates and one may identify internal sub-orthogonal axis.

The proximity of the three considered centres, far 16 kilometers and well connected to each other, and the architectural and environmental features that characterize them allowed us to carry out a organic strategy for redevelopment.

The area, infact, is well connected to the state capital L'Aquila through the state highway SS261 and to other centres thanks to the presence of the railroad. The economy of the area, mainly agricultural, in recent years saw the development of a modest tourist activity, for the presence of a morphologically varied territory and for the naturalist beauty, wherein is distinguished the presence of the famous Caves of Stiffe and the Sirente Velino Park (Centofanti M., 1975).

Design scenarios and technological applications

The design idea for the case study is to re-create a strong regional system by exploiting climatic and economic peculiarities of each centres taken into account.

We assumed a series of design scenarios that, overlapped, allow the application of different and complementary strategies using technological solutions case-by-case.

The technological scenario must be supported firstly by a functional rehabilitation, for the creation, for example, of a residential-tourist itinerary, based on several peculiarities of the territory: the presence of the Caverns of Stiffe and the Sirente-Velino Park contribute to increasing the interest for a part of region still little known.

However, many cases of redevelopment with touristic purposes show that in these inland areas is not enough trust on tourism to bring back population and work. Therefore we looks with interest the redevelopment of the typical local activities, primarily related to production and sale of local products (truffles, saffron, lentils, etc ...) and the strengthening of relevant occupational activities, such as the presence of an important health helpful reality in Fontecchio.

Furthermore, it is essential to create new forms of housing suitable by contemporary users (often young couples or singles). The idea is design some areas for co-housing: for example the southern area of the square of St. Eusanio, mainly hit by the earthquake, introducing technological solutions in open spaces that characterize this area, or supporting local initiatives such as the home-workshop of Fontecchio.

So becomes fundamental also the scenario of sustainable mobility, to ensure accessibility to these countries. This involves the upgrading of local road network and connections with the major production towns and the improvement of public transport. Moreover is expected the strengthening of bike paths system, now present just in few streets, the railway connecting the considered centres, and the introduction of new forms of sustainable mobility, such as car-sharing and bike-sharing (Fig. 3).

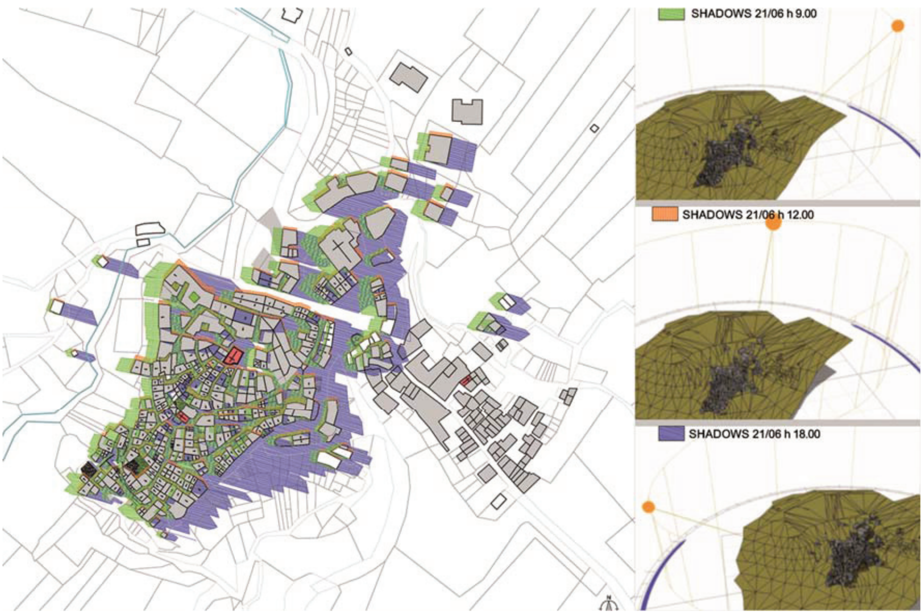

Figure 3. The scenario of sustainable mobility (Design by Marchionni C.).

The technological scenario, therefore, has been developed as a synthesis of knowledge phase, which has highlighted the critical climatic and those relating to technology networks, as well as the presence of environmental features to be strengthened.

In the centre of Fontecchio, for example, was compatible from the environmental point of view the application of technologies linked to the exploitation of biomass and solar energy.

For the biomass evaluation was firstly verified the presence of local biomass, thanks to observations in situ and data provided by the Forest Guard of L'Aquila, finding the availability of the raw material as waste and the presence of a short chain.

Regarding solar energy, the arrangement of Fontecchio on a significantly slope valley, with predominant exposure to the south-west, has left open the possibility of integrating photovoltaics and solar thermal technologies into the historical fabric.

We carried out a verification of the areas in conditions of persistent sunshine thanks to the 3D reconstruction of the villages and the further use of the software Ecotect which has also allowed to evaluate the main climatic and biophysical critical situation, in winter and in summer, mainly due to ventilation, sunshine and nature of soils (Fig. 4).

Among these the presence of a lot of zones with problems of lack of natural lighting of the streets and fronts northward exposed and a lot of moisture on the ground, due to the absence of solar penetration and an efficient system of drainage. Furthermore there are no large open spaces sunny, on the contrary in San Pio, but whole fronts in overheating risk, those of walls-houses southern facing.

Figure 4. Map of shadows in summer of Fontecchio and 3D views (Design by Marchionni C.).

Considered the available energy sources, the design choice was oriented on the deployment of a mix of micro-interventions, both in respect of the construction characteristics of the country and the pursuit of reduced environmental impact, and in view of cyclically variable consumption.

A design application has watched with interest to the area to the south part of the village: here the technological scenario has followed that related to the functional aspects and the mobility, recovering the area for residential purposes, with the upgrading of existing guest quarters through the introduction of commercial services and the recovery of the usability of open spaces through their urban regeneration, first of all the Chiassetto of Caia.

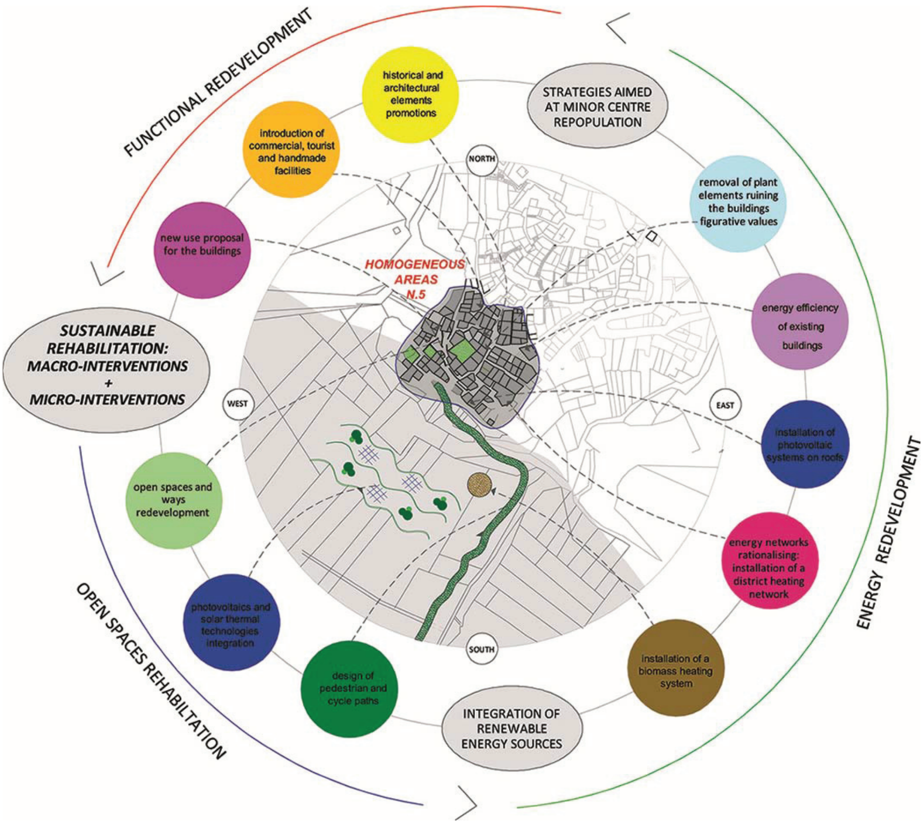

Figure 5. Sustainable strategies for the design area in Fontecchio (Design by Marchionni C., Di Natale A., De Angelis A.).

Regarding mobility and accessibility of the area, however, it has been hypothesized a development of the pedestrian path that connects the area to the wall houses situated to the north of the village, called Caia way, and the opposite way Piedi la Terra, that connects to the west area of the old centre.

To the south, however, the area is accessible through a pedestrian path, not used now, which is connected with the most downstream area, where there is a carriage road, called Via 1, which leads to the railway station. We hypothesized the recovery of this path through the ground arrangement and the introduction of high-performance energy lighting systems.

The rehabilitation of energy networks is characterized, however, by the adoption of a district heating system extended to the whole area, powered by a biomass power plant, a choice that involves three basic steps:

- calculation of the heat demand for the plant design;
- identification of the site to place thermal power plant;
- identification of the distribution system.

The choice to hypothesize a lot of small district heating networks, and not a single network in service of the whole village is dictated by several considerations: the site analysis, characterized by streets of small size and very sloping; the environmental impact that the introduction in the territory of a thermal power plant of considerable size may have. Finally, the risk of over-sizing the thermal power plant, since there is no stable usage.

In order to exploit solar energy too, the power plant will be electrically powered by a system of photovoltaic panels in polycrystalline silicon.

To complete the technological scenario, in order to meet the needs of the area of interest, it has been provided also the installation of photovoltaic systems on the roof of some buildings with a minor historic value and best orientation, such as, for example, the guestrooms.

It is also provided the formation of technological urban gardens in the green area south of the sector part, supposing the installation of well integrated photovoltaic terracing.

In the centre of Sant'Eusanio, instead, the presence of a high degradation and numerous collapses due to the earthquake allow us to hypothesize a modernization of networks, now insufficient and poorly functioning, reasoning on the entire village. Here it's possible the creation of an underground technological tunnel, which path is designed in order to be respectful of valuable paving. This allows the elimination of many technological additions and reduction of problems about inspection.

In the margin southern area of the village of San Pio, however, flatter and greater, was designed the creation of technological urban gardens. This area, well exposed to sunlight and summer breezes, and away from important and valuable buildings, was partitioned in order to be enjoyed by multiple users, and here was promoted the application of renewable energy technologies to be integrated into natural and realization of a system of accumulation and reuse of rainwater.

The application of the identified solutions occurred just after the compatibility verification with the environment, a compatibility under different aspects (environmental, technological, functional, economic) followed by indication of reversibility degree.

Conclusions and future developments

The test on case studies shows how, recognized on the one hand the values to be respected, on the other hand the need to introduce forms of energy efficiency, it is possible to overcome the normative and bureaucratic impasse that now prevents the recovery of abandoned territories.

The methodology is intended to be a support tool to main actors related to the post-seismic reconstruction, therefore public managements and designers.

In particular, to the first we would provide a tool that overcomes the present incompatibility in SEAP (Sustainable Energy Action Plan), in order to combine the mere physical towns reconstruction with the technological and energy one.

This methodology, which can be enriched with a lot of technological solutions offered by the current market, provides an organic method that avoids the simple application of standard solutions and use of market products, but rather prefers the approach to the single case, that is a key concept if we truly want to respect and take advantage of the specificity of each context.

However, even if it starts from the specific investigation context, which determines many of the elaborated considerations, the intention of the developed methodology is to provide meta-planning indications generally applicable to other sensitive areas hit by emergency situations.

The next phase of the research aims at increasing the multi-disciplinary contributions related to the recovery process of the countries. In particular it is considered valid, in phase of knowledge, the deepening obtained by the use of technology by UAV (unmanned aerial vehicle) for evaluation and thermographic study. For the scenarios validation, however, it is necessary to enrich the methodology considering the economic component and the control of the management and maintenance process.

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