Designing Resilience

edited by

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adaptation from:
Piet Mondrian, *The Gray Tree*, 1911

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1.6 REGENERATION AND RESILIENCE: STRATEGIES TO CLOSE THE LOOP FOR THE FUTURE OF THE BUILT ENVIRONMENT

Maria Rita Pinto[*], Cinzia Talamo*[**], Serena Viola*[***], Giancarlo Paganin*[****]

Considering the issue of resilience in the definition of regeneration and maintenance strategies for the built environment requires rethinking the boundaries and properties that characterize the traditional fields of investigation and intervention related to settlement systems. At the same time there is the need to identify innovative paradigms to manage the relations between artefacts, contexts, events - predictable and non-predictable - that can modify the expected functionality in a progressive or disruptive way, with the aim of ensuring the identity of the settlement systems and enhancing their resilience.

In the paper, the resilience approach is developed according to two complementary perspectives:

- on the one hand, the framing of cultural synergies between the concepts of fragility, vulnerability, robustness, reliability and adaptability and the issues of maintenance and regeneration, focusing on the specificities of the information management process;
- on the other hand, the identification of projects and tools for the development and implementation of pilot experiments developed in the territories.

From fragile systems to resilient systems

Fragility and vulnerability are two terms often used as synonyms to represent, for a generic system, the scarce capacity to bear without consequences the exposure to a potential variability of its boundary conditions. In everyday language it is considered fragile something that breaks easily, with the tendency to summarize the general concept of fragility essentially in its consequences,

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namely the easy break. For the built environment it seems instead more interesting to focus on the point of view that looks first to the causes and secondly to the consequences that these causes are able to generate. Fragility can therefore be described as the condition of an element or system in which a change, even if limited, of one or more state variables can result in negative consequences of great importance for the system. For a fragile system, the consequences are usually characterized by a non-linearity with respect to the causes that generated them: a moderate increase in the magnitude of the stress in a fragile system can lead to significant increases in the negative effects generated on the system (Derbyshire and Wright, 2014; Taleb and Douady, 2013).

Another feature that can be highlighted in fragile systems is the one concerning the asymmetry between positive and negative effects: in a fragile system the benefits given by the stresses on the system tend to be limited, while the negative effects can be much more relevant[1]. This behaviour, when dealing with the issue of fragility at the scale of the built environment, is made more complex by the fact that the non-linearity of the different performances may be different, thus making it important to analyse the potential of the various performances to move away from the condition of equilibrium. The building then assumes different levels of fragility with respect to the performances that it is required to provide: some fragilities may have a more significant variability, thus being more critical than other performances that could instead be less influenced by changes in operating conditions.

Some authors (Johnson and Gheorghe, 2013) tend to differentiate the concepts of fragility and vulnerability in relation to endogenous or exogenous factors to the system under examination; systems are vulnerable when they suffer consequences because of their degree of exposure to stress factors, while they are fragile when they lose their characteristics regardless of the nature of the stress factors to which they are exposed. Vulnerability is exogenous susceptibility while fragility is endogenous susceptibility.

The robustness of a system is often defined as the ability to withstand a not completely defined set of events in such a way as to avoid unwanted consequences. Compared to a resistant system - typical of engineered systems that are designed to provide a definite response to a deterministic framework of actions - a robust system is able to withstand "approximation or ignorance" (Roy, 2010) to avoid impacts that are unacceptable or otherwise unwanted. In some ways the robustness of a system could be confused with its reliability because in both cases the expected result is that the system works as expected: in fact, the difference between the two properties consists in the fact that a reliable system remains unchanged in the scope of the operating conditions assumed in the

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1 As an example, in winter conditions the operation of an heating system can bring a benefit, compared to the conditions of well-being, limited to two, three degrees of temperature increase; if instead the system does not work the consequence can be a temperature decrease equal to 5-6 times the maximum potential benefit.

design while a robust system is such when it is able to remain unchanged even outside the operating conditions envisaged in the design. A robust system is therefore able to achieve its operating objectives - keeping its state and configuration unchanged - even when stressed by events outside its normal operating range. When the ability to resist stress factors is associated with a change, even temporary, of status and configuration that are later restored to the original conditions thanks to recovery processes, then from the concept of robustness we move on to the resilience concept.

A resilient built environment can be defined (Bosher, 2008) as the one that is designed, constructed and managed in such a way as to maximize its ability - combined with the ability of support systems and of people who use it for various purposes - to withstand, recover or mitigate the impacts of adverse events. Assuming this definition, it seems inappropriate to use the term resilient associated with the building in the strict sense, considering only its intrinsic characteristics deriving from its design and its construction. Rather it is the set building-use-management that can completely cover the different dimensions (Burroughs, 2017) of resilience: physical, infrastructural, environmental, socio-economic, political-normative and organizational.

Speaking of resilience and built environment we should also take into consideration the following three fundamental aspects (Burroughs, 2017): resilience "of what", resilience "for whom" and resilience "with respect to what". The first question concerns the scale at which one intends to assess the resilience that can go from a single building up to the urban scale. The second theme is particularly relevant to the built environment, because it proposes a different reading according to the subject considered to be the main stakeholder in determining the resilience of the building: it can be the local administration, the property or, again, the set of the different users or the construction industry, understood as an aggregate of builders, suppliers and designers. On the basis of the point of view taken from the previous point, the framework of scenarios and stress factors to be considered in the assessment of resilience may vary.

A resilient system has some characteristics and abilities that characterize it (Aven, 2016; De Florio, 2013):

- it reacts to regular and irregular stresses in a robust and adaptive manner;
- it is able to constantly monitor the events and operating conditions, including its performance, becoming promptly aware of the events that happen in the environment in which it operates;
- it has the ability to anticipate positive and negative risks associated with particular events;
- it learns from its own experience and has the ability to use awareness to prepare a response to changes that are encountered.

Through an appropriate mix of monitoring, fast detection and quick response, the negative consequences of events can therefore be avoided or mitigated. These characteristics share the topic of the availability of information and data that becomes a particularly interesting point of view for a contextualization of the theme of resilience within the built environment.

Resilience, risk and information

One of the multiple points of view to consider resilience, in terms of innovative approaches to the regeneration and maintenance of the built environment, is information.

In particular, an analysis centred on the role of information with respect to resilience can focus on two aspects:
- the relationship between predictability and unpredictability of events in relation to risk management;
- the integration of information systems with social, physical and infrastructural systems.

It is evident that the ability to manage risks is an important condition to support the resilience of the built environment. As many studies and regulatory guidelines[2] highlight, the risk management processes are based on the ability to systematically activate multiple activities, involving a plurality of different subjects. These activities - essentially of cognitive, evaluative and decisional nature - concern: the definition of the reference context and the identification of the criteria for recognition and measurement of risks; risk assessment through sequential actions of identification, analysis and evaluation; risk treatment with the identification of possible strategies and alternative actions, which can be activated in order to prevent or mitigate risks by acting on the possible sources or manage them by acting on the expected and foreseeable effects (Wilkinson et al., 2015).

The possibility of developing these types of processes depends significantly on the ability to manage information in different ways in the actions of: collection, consultation and communication within a plurality of stakeholders (information sharing), monitoring and control (information feedback), reporting and processing (collection and statistical processing of information).

Surely the ability to recognize and manage risks is an important contribution to the resilience of the built environment which however - as many sources point out (Arup and Rockefeller Foundation, 2014; Comes et al., 2014) - needs integrative strategies because of the variability of the events that may involve it, many of which are unpredictable and with a significant complexity of their interconnections. Strategies capable of overcoming the static approach based on the preventive recognition of specific - and sectorially circumscribed - hazards and the forecasting of their possible occurrence. If, therefore, risk management

[2] ISO/FDIS 31000:2017 (Final draft), "Risk management. Guidelines", IEC/ISO 31010: 2009 "Risk management - Risk assessment techniques".

appears to be useful for managing those components of resilience identified as robustness and reliability, different approaches shall be identified to assume at the same time the issue of non-predictability (both in terms of isolated and sudden events and of progressive events) of the systems interconnections and interdependencies (O'Rourke, 2007; Morin, 1993), and of their adaptive and reactive capacities.

In particular, with respect to the topic of interdependence, interesting is the study by Rockefeller Foundation and Arup (Arup and Rockefeller Foundation, 2014) which recognizes the city, and more generally the built environment, in its various components as a "system of systems" to be analysed and managed in its resilience capacity according to a performance-based approach. An approach that intends to overcome the analysis of the resilience of the individual subsystems and which aims to assess the resilient capacities of complex systems in reacting, through their physical and non-physical components, to disturbing events (stress and/or shock), ensuring some fundamental functions identified such as: fulfilment of basic needs; safeguarding human life; protection, maintenance and increase in the assets performance; facilitation of human relations and identity recognition; promotion of knowledge; defence of the law; support for sustenance; economic prosperity. These are "cross functions" that require continuous exchanges and interactions between systems concerning different dimensions (Comes et al., 2014) - technological, organizational, economic, social, etc. - and which presuppose, at the level of a single system[3] (or sub-system[4]) and a "system of systems", the coexistence of different qualities, such as: ability to reflect[5], robustness[6], redundancy, flexibility[7], ability to access resources, inclusiveness[8], integration[9].

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3 For example, infrastructures.

4 For example the road infrastructures.

5 Important is the ability of systems to learn quickly from past (but also ongoing) experiences in order to interpret dynamic scenarios and activate adaptive strategies. The necessary capacity to collect, process and distribute information (contextualised data, experiences, good practices, etc.) is evident in order to achieve an adaptive intelligence of the system. See also: Rosenberg, 1982; Ackoff, 1989.

6 As already mentioned, robustness represents the ability of a system to withstand the expected unwanted events without losing functionality. It is evident that the robustness - which depends on the planning, implementation and maintenance of the systems - referring to probabilistically predictable events, benefits from the continuous collection of information: the progressive enlargement of the statistical base allows, with the improvement of the forecasts, to pursue strategies and solutions adhering to the level of risk envisaged in relation to the criticality attributed to the systems.

7 Flexibility, as an ability to adapt efficiently to changing or changed circumstances, can be pursued through strategies based on decentralization and the modularity of the components of the systems, as well as on the ability to activate, better if with the support of technologies, information exchanges, knowledge and skills (Tilstone et al., 2013).

8 In the sphere of social systems, inclusiveness allows to avoid the isolation of individuals or groups and, also through the use of various information tools, the involvement - spontaneous or guided -

Among the intangible factors that contribute to maintaining and sustaining the functions and qualities of a "system of systems" resilience, such as the built environment, surely information plays an important role for its multiple uses: real time data monitoring, creation and dissemination of shared knowledge, development of scenarios for decision makers, verification of interactions and synergies (positive and negative) between systems, diagnosis of phenomena, activation of adaptive and reactive condition based strategies, etc. Surely the design and management of the built environment, in a perspective of resilience, shall carefully consider the issue of information, identifying mutual influences, that is how the systems constituting the built environment can be configured with respect to different information management strategies and, vice versa, how information management systems should be structured. It is clear that the management of information, in order to support the reactivity to the often unexpected and disruptive events of complex systems, cannot ignore the problems of heterogeneity, multiscalarity, interconnection and interrelation of data sources, quality and reliability of information, generation and distribution of data, interoperability of processing systems, management of information flows, etc.

In this regard, interesting is the contribution of the study by Internews (Internews, 2015), which introduces the concept of "information ecosystems", to be understood as a structure, a framework, able to represent the general framework of information of the entire "system of systems" and to receive requests for knowledge from the various interacting systems. The interesting aspect of this approach consists in designing the informational supports for the purpose of resilience through the analysis of specific contexts, starting from the assumption that the processes of identification of knowledge needs, of creation and distribution of information are translated into fluid systems that dynamically adapt and transform themselves in relation to the problems, needs and challenges of specific communities/systems, also influencing the adoption and impact of new technologies. This approach, based on the reading of information flows with respect to relationships between interacting systems, combines the information analysis at the macro level of the "system of systems" with the more detailed investigations at the level of the constituent systems and with the analyses on the human and social systems (for example by identifying information disseminators and influencers, uses and impacts).The idea behind this approach is that the quality of information and its appropriateness with respect to different contexts can create the conditions for these to be appropriately implemented and exchanged in order to allow communities to anticipate, interpret, plan and re-

of the whole community in sharing problems and searching for solutions (Tilstone et al., 2013).

[9] The integration and the alignment between interconnected systems, at different scales and between different operators, is fundamental for an overall vision of the events and changes (endogenous and exogenous) to the systems and to provide decision-makers with orientation elements for their choices and for the verification that investments have the possibility to widen their effects as much as possible in the community.

spond to changes in terms of resilience.

Design, resilience and future of the built environment

In built environment regeneration, the technological innovation drives and is driven by the changed cultural and settlement conditions and by the process of modification and renewal, generated by new environmental, social and economic challenges. The consolidated settlement systems are traditionally marked by the adaptability to disruptive events and have come to the present day thanks to their being resilient systems. In the current scenario, the regeneration project must therefore accept this character, reinforcing the dynamic and evolutionary dimension of the built environment, which characterize the material culture as a response to the evolution of user needs (Mannoni, 2003).

In regeneration and maintenance the identifying characteristics and, at the same time, the diversity of settlement systems shall be consolidated and valorised both through the attribution of value by the communities and through the reflection on new values to be created, with the aim to identify and to increase the "resilience thresholds" (Fabbricatti, 2013). With a view to capacity building the user's role changes: from the user of a service offered by someone else to a subject responsible for the phases of implementation and management of the service itself.

The need for research in relation to resilience goes through all the different phases of the regeneration/transformation process for the built environment. In the case of preliminary planning and schematic design, the need arises to define resilience indicators aimed at evaluating, at different project scales, the degree of response to pressures/disturbances in progress, foreseeable or unexpected; in the design development phase, it is appropriate to identify new types of performances, and related indicators, that allow to define design choices aimed at resilient development scenarios. The implementation/management of the actions envisaged by the regeneration and maintenance project also requires the assignment of a new role to the user and the early activation of possible feedback circuits and self-regulation systems. Monitoring becomes a strategic action to be carried out by means of variables that control the dynamics in progress and the thresholds of acceptability of transformations, with reference to the different contexts. In relation to the priorities and research issues that arise in the field of regeneration and maintenance of the built environment, the aims to be pursued concern the following:

- reconnaissance of the demand for innovation posed by the actors involved in the processes of transformation/conservation of the built assets, in the local specificity of the contexts;
- definition of performance dimensions and of the related indicators which, in relation to the objective of resilience, allow to elaborate new scenarios and to

evaluate trends in progress, in relation to the different scales of the project;
- definition of measures/actions (also based on good practices) that can be introduced to increase the ability of buildings and urban systems to respond to stress, restoring conditions of balance or creating new ones;
- definition of the role that users can assume in the implementation and management of the maintenance service, also taking into account the notion of an open and adaptive settlement (Ciribini, 1986), with the aim of reconstructing the link between people, territory and artefacts, promoting community and sharing of permanence and change choices.

Experimenting in the territories: the M'arte laboratory in Praiano

An opportunity to validate the theoretical assumptions stated is the prefiguration of drivers for rebalancing the decomposed development of high vulnerability settlements, through design experimentation. The cultural paradigms of resilience are declined through regeneration and maintenance laboratories, with the aim of creating synergistic processes for sustainable development (Fusco Girard, 2010). In response to the pressures that erode the sedimented qualities of the built environment (Beguinot, 2011), the Research Cluster Regeneration and Maintenance identifies in the laboratory an operational and procedural model, able to activate unprecedented relationships between knowledge and know-how, triggering conditions of dialogue between institutions, entrepreneurship and public administrations (Pinto and Viola, 2016).

The formula of the laboratory emerges from the need for knowledge about the processes that affect the contexts, with the need to involve large and motivated communities, so that the circular relationship between places, material culture and lifestyles can give rise to an explanation of needs, attentive to compatibility and aware of the consequences for the project scenarios (Viola, 2012).

The nodal focus of experimentation is the construction of temporal alliances, between past and future, through the identification of built environments' resilience degree and the extrapolation of latent potentials still unexpressed in the physical, social and economic systems. The Research Cluster cooperates with the Municipalities, to the construction of alternative design scenarios, recognizing the sedimentation of memory and material culture as drivers for transformation and appropriate development (Caterina, 2016). The foundation of the experiments is the hypothesis of a circular process, in which knowledge contributes to giving life to a community through the re-aggregation of shared knowledge, in order to produce awareness; it opens to the consultation of appropriate transitions, starting from the characters of resilience inherent in settlement systems (Nevens et al., 2013).

Combining social cohesion, competitiveness and technological innovation is the challenge at the centre of the experience realized in Praiano, the UNESCO site of the Amalfi Coast. Faced with the lack of co-evolutionary dynamics, which for centuries linked communities and places, M'Arte Lab recognizes in the artistic production a driver of change for rebalancing past transitions[10]. Marginal conditions due to the difficult accessibility and erosion of the settlement qualities, due to seasonal tourism residences, are at the origin of the perturbative pressures that impact on the built environment. The laboratory, creative environment in which expert knowledge and established community negotiate through design the future, outlines two lines of action for strengthening resilience:

- to hybridize the use of art between public and private space, promoting awareness of the historical urban landscape and of the artworks made in the last fifty years by artists of international origin;
- to experiment new opportunities for symbiosis between art, technology and settlement, encouraging the design of technological solutions "to protect" the vulnerable elements of the building (window frames, vaults).

Involving local artists, artisans and local firms, the Praiano laboratory is at the same time a place of cultural production and incubator of entrepreneurial initiatives throughout the Amalfi Coast. In this vision, regeneration and maintenance are shared and incremental processes, carried out through micro actions directly managed by a context-aware community. The creation of a system of small and medium-sized enterprises able to operate with technological appropriateness on the built assets is a predisposing condition to the resilience of the settlement.

Experiencing the symbiosis between memory, art and regeneration, the experiences of the Research Cluster on the territories reactivate the intrinsic reaction capacity of the settlement to the impacts of perturbative pressures. Recreating a culture of conservation and care for built assets, the Research Cluster gives back to the community an ancient ability to be, at the same time, custodians of heritage and intermediaries of innovation.

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[10] After the Second World War, the almost permanent presence of artists, who lived for long periods of the year in close contact with the inhabitants, helped to characterize the settlement's culture. Over the past few decades, an unprecedented tourist development affected the Municipality; this process can be assumed as a reflection of the tourist and economic boom that affected the entire Amalfi Coast, while the flow of artists in connection with Praiano thinned out almost to a halt.

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