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Seismic Risk Reduction: a Proposal for Identifying Elements Enhancing Resilience of Territorial Systems

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1 ABSTRACT

Facing the complexity of urban and regional systems, as they are characterized by several elements continuously interacting each other and making complex governance in ordinary and extra-ordinary conditions, tools for manage strategic choices could be suitable. Therefore, due to the systems complexity, often it is needed, before to identify strategies, to clarify what the problem is, and clearly consider all relevant aspects.

In this paper, we present a Strategic Option Development Analysis (SODA), applied to the problem of seismic risk reduction, with involvement of different kinds of stakeholders, acting on territory with several roles. The problem structuring has highlighted which are the components, in terms of available tools, elements on the territorial systems, stakeholders, etc. contributing to enhance resilience, as we recognize that this is the main characteristic that a system must have in order to answer to a seismic event.

The paper is organized as follows: in the second paragraph, a framework concerning the seismic risk problem and the relationship between seismic risk and resilience. The third paragraph contains a deepening concerning resilience, and in the fourth is finally presented the approach applied to the problem of seismic risk reduction, the SODA. Results of adopted approach are presented in the fifth paragraph.

2 SEISMIC RISK AND RESILIENCE

Natural disasters, nevertheless continuous scientific and technological development, cannot be avoided, and, as history too often teaches, when a calamitous event occurs, it produces high damages. The learned lesson seems to be that prevention strategies are not adopted in order to mitigate possible damages, but generally interventions follow a catastrophic event, trying to mitigate its effects.

Therefore, as mentioned, scientific and technological development continuously gives some contributes to handle natural disasters, and produce results in terms of strategies to adopt before a risk crisis; considering the possibility of such disasters, with a defined risk assessment, we must work in order to face them, and to react, with at least as possible loss, in terms of lives, injured people, damages on buildings and infrastructures and indirect effects. First of all, we need to know what to do to face emergency conditions; then, how to manage crisis in order to limit damages caused by natural and other disasters and finally to go over crisis and to guarantee the re-establishment of ordinary conditions.

Risk assessment takes into account several components: generally, it is defined as a function of hazard, exposure and vulnerability (UNDRO,1980). Hazard concerns natural characteristics of a natural phenomenon; for instance, if we consider seismic risk, hazard depends on historical seismic characteristics, ground geological characteristics, geotectonic and seismic-genetic structure characteristics, which do not depend on human intervention, so that we are not able to control them.

Exposure, instead, concerns the human presence in a certain area. So, if hazard conditions are worrying (i.e. hazard is high), then human settlements must not be established there. Anyway, generally knowledge about hazard is subsequent to settlements, stratified during the centuries, so that displacement represents a strong decision with several impacts on inhabitants. Concerning the not yet urbanized areas, instead, hazard knowledge is strategic in order to allow a rational and safe planning.

The third component is vulnerability, that is defined as the tendency of a certain element to be subjected to damages or corruptions, depending on its own physical and functional characteristics (Fera, 1997). Generally, vulnerability is referred to the elements composing a settlement; in the case of seismic risk, for instance, vulnerability mainly refers to seismic vulnerability of buildings, and other structures, as roads, bridges and so on, and its evaluation depends on structural characteristics, determining building behavior in case of seismic actions. Technical codes supply building criteria taking into account the relation between the structure and the hazard on its location.

In the last decades, anyway, the concept of vulnerability has been presented also with a wider meaning, considering it at urban scale. Considering for instance Manyena (2006), it has been recognized that global activity in a town can be compared to activity of a network system, where each edge, working at local level, contributes at global level. From this point of view, it becomes evident that physical damages are not unique components of global damage. Moreover, it has been observed that earthquake effects are not limited to physical damages, but they have some ripples on economic, social and political activities, and they have a strong role onto city capacity to react.

This framework, taking into account the wider concept of vulnerability, leads to a new approach in risk prevention, going over building structural adjustments, and highlighting that single components work as a whole system, in which it is possible to recognize not only physical elements, such as buildings and streets, but also social, economic and political functions.

New approaches must define tools able to mitigate such urban seismic vulnerability; therefore, it should forecast, before a seismic event, what kind of response the single components might show. Such an approach aiming at mitigating urban seismic vulnerability, must maximize system resilience, as the capacity of a certain system to adapt to new, generally negative conditions, to re-establish normality (Comfort, 1999).

3 RESILIENCE: GENERAL FRAMEWORK

The International Strategy for Disaster Reduction, Hyogo Framework for Action 2005-2015, defines resilience as the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure, and that is determined by the degree to which the social system is capable of organizing itself to increase its capacity of learning from past disasters for better future protection and to improve risk reduction measures. Not accidentally the strategy is exactly called Building the resilience of nations and communities to disasters: resilience concept is placed at the core of strategies.

In origin, the concept has been developed in the field of ecology: following the Holling (1973) definition, it is a property of a system, measuring its ability to absorb changes of state variables, driving variables and parameters and still persist; the concept is strictly related to that of stability, intended as the ability of a system to return to an equilibrium state after temporary disturbance. In the risk management literature, resilience to natural hazards is defined (Pelling 2003) as the ability of an actor to cope with or to adapt to hazard stress. It is a product of the degree of planned preparation undertaken in the light of potential hazard, and spontaneous or premeditated adjustments made in response to felt hazard, including relief and reuse.

In the concept of resilience it is possible to recognize also a social dimension: according to Bruneau et al. (2006), community seismic resilience is defined as the ability of social units to mitigate hazards, to contain the effects of disasters when they occur, and to carry their recovery activities in ways that minimize social disruption and mitigate the effects of future earthquakes. This can be achieved both working on structural aspects and emergency response and strategies, involving institutions and organizations, and in particular those related to essential functions for community well-being, as acute-care hospitals. Communities must be capable of coping a stress situation, where they must manage demands, challenges and changes, with available resources and competences (Paton et al., 2001). In the Godshalk (2003) vision, community networks must be able to survive and function under extreme condition, as condition sine qua non the city system will be vulnerable.

Considering resilience as a property of each system component and of the whole system, anyway, is not helpful in order to identify strategies. How to measure this property? How to put in action strategies working on components and on the global system at the same time? How to recognize the augmented resilience before a disaster? Obviously, this is not a unique aspect to be considered. Considering natural disasters, several strategies could lead to enhance resilience in terms of augmented capacity of absorption and recovering from changes (Barnett, 2001), referring to resilience properties. Bruneau et al. (2006) consider that resilience is characterized by almost four main properties:

- the robustness, as the ability of elements to resist to a certain stress, without suffering degradation or loss of functionality;

- the resourcefulness, as the capacity of identifying problems and finding solutions depending on priorities and available resources;
- the ability, as the capacity to meet priorities and to achieve goals as quickly as possible;
- the redundancy, as the substitutability of elements in order to satisfy some requirements no more satisfied by a degraded element.

Even if such properties seem to be abstract, they can find a concrete application. For instance, decentralization of decision making (i.e. creating several decision making centers in a town) or strategies about mobility, generally refer to redundancy, and so on.

Paton et al. (2001) define a resilient city as a sustainable network of physical systems and human communities, where the first ones include all kind of structures and infrastructures, acting as the body of the city, its bones, arteries, and muscles, and the second ones represent the social and institutional components of the city, including all kind of associations and organizations and acting as the brain of the city, directing its activities, responding to its needs, and learning from its experience. The metaphor makes clear that during and after a stress, both systems are determinant: if body collapses, the entire system collapses; if brain breaks down, the entire system breaks down.

Therefore, the most important aspect concerns how to define and apply strategies. Observing cities, they can be modeled as network systems, with a main trunk, hierarchically more important than some secondary branches. In terms of response to a disaster event, therefore, trunk elements must have a faster response, because they are charged of main activities of city, and moreover they represent place identity.

4 HOW TO IDENTIFY RESILIENCE: THE PROPOSED APPROACH

The last two sections open several issues, but not yet show the way to identify elements to enhance territorial systems resilience: they show exactly the research process, that, at this point, lead us to a precise conviction. We are at now persuaded that the seismic risk mitigation is a particular kind of problem, that we are not able to solve with traditional paradigms of operative research, but, that need a preparative phase of structuring.

Seismic risk mitigation involve several stakeholders, with several different expertise, and a different role in a particular field of city and territorial systems organization. Therefore, the problem needs to be handled at several reference scale, considering differences between the quarter, the city, the region, and in a context of knowledge more and more precise, but not exact, so that we are facing with a problem – the earthquake occurrence – that we don’t know exactly when, how and where it will occur.

Moreover, we recognize that a strong component of resilience is related to communities, that must be involved in a something, as a participative process, to be prepared.

In this huge amount of aspects to be considered, and in front of the exigency to involve the stakeholders, the most helpful tool, we thought, could be starting from the problem structuring. So, the proposed approach, Strategic Option Development Analysis, in order to develop a participative process, build a cognitive map representing the problem and highlight, with the stakeholder contribution, which are the elements enhancing resilience.

4.1 trategic Option Development Analysis

SODA (Eden, Ackermann, 2001) is a method aiming at identify general problems with the support of cognitive mapping, in a participative context, where actors are related to the main issue, and need to agree about possible solutions. The method is of the techniques of the family of problem structuring, suitable when it is not possible to adopt classic method of operative research, because problem nature is not well clarified, there are qualitative and quantitative aspects, there are several points of view to take into account, several actors, knowledge is not exact, consequences of potential actions are not certain and so on.

Main idea is to focus on the problem, and, with creativity and spontaneity, identify all elements related to the problem, in terms of sub-problems, causes, effects, other related problems etc. Discussing around the problem helps each participant to clarify its ideas, and to enrich its store of knowledge also with contributes from other participants. Conflicts can be solved, finding evidence for their existence, and identifying small actions toward an overall objective, that everyone shares, and obviously is related to the resolution of problematic situation.

The method is based on the hypothesis, helping in the process development, that a best solution cannot exist, but that it is therefore possible identify partial solution, steps towards a solution, conflicts resolution, and that the participative process produce anyway a positive result.

Kelly (1955)' theory of personal construct is adopted in the SODA approach. In brief, the theory affirms that each subject, affected by his own experience and cultural background, looks at the world and builds a representation through a systems of concepts. He defines concepts in natural language, and considering his emotional component. Therefore, in a participative context, several subjects are involved to contribute to a shared vision of the particular problematic situation: the discussion can produce a map, as a merge of the entire concept that each subject can express, and identifying common relations.

Generally, SODA approach is adopted in several steps. First one is characterized by individual interviews, during which the facilitator helps the interviewed subject to express ideas concerning problematic situation, and represents these ideas on a cognitive map. Once all interviews have been carried out, a collective workshop is organized. Facilitator presents a merged map, derived from the single maps, and helps subjects during discussion.

The merging phase is strategic, in order to allow each subject to identify in the merged map its personal contribute, but at the same time, it is important to highlight conflicts, and work, during workshop, on their resolution. This last passage leads to a team map, containing also identification of strategies and actions. As mentioned, not always it is possible to identify a solution, but anyway, the shared vision of the problem is an important result.

4.2 Cognitive mapping

SODA main goal is to clarify the problematic situation and identify possible solutions, through a shared representation, that make possible to take into account qualitative aspects, and at the same time highlights the importance of relations between elements in the situation. For this aspect, cognitive mapping is a suitable technique. Maps are something that everyone builds in its mind every time he searches for the meaning of world. As Kelly (1955) affirms, in the attempt to give meanings to the world, men build a concepts system, where the number of concepts is limited, and each concept is conceived in relation to some personal emotional perceptions. Then, concepts are hierarchically organized, identifying some cause-effect relations. In the SODA context, cognitive maps are representation about a problem. They are composed as a network with edges and nodes. The direction of an edge defines a hierarchy, and usually denotes causality.

Once maps are conceived, it is possible perform some analysis in order to highlight particular aspects; for instance, the shape of the map helps to identify the complexity level of problem. When a map is plate, there is no evidence of a strong hierarchy between concepts, and on contrary, with a pyramidal structure, it becomes evident the presence of a reduced number of heads, and of some predominant concepts, and so on. Another interesting aspect is related to number of edges entering in a particular node: this denotes the relative importance of node compared to other ones.

The possibility to automatically perform analysis is particularly useful when the map reaches a large number of concepts, making difficult reading; analysis, moreover, help to identify contradictions and conflicts, often present in a merge map, obtained starting from individual maps.

In this research, Decision Explorer software has been used in order to build the map and, then, to perform the analysis. Decision Explorer is software developed at Bath and Strathclyde University, as a tool for managing soft issues, as the qualitative information surrounding complex and uncertain situations, and at not developed by Banxia Software.

It is important to clarify that cognitive maps generally are built in order to better understand a specific problematic situation, sharing with other involved stakeholders, and not to build a knowledge model. As declared, also the cognitive map that has been realized does not represent a knowledge model about seismic risk.

5 THE ROAD TO A SHARED MAP ABOUT SEISMIC RISK MITIGATION

In order to reach our research goal, a workshop has been organized, inviting several experts on seismic risk mitigation. In particular, the experts comes from the field of seismic risk, the field of Civil Protection and the field of urban and spatial planning, and they have been chosen in a large variety of different expertise.

During the identification phase of possible involved stakeholders, it emerged that seismic risk mitigation is a very large field, interesting institutions and scientists, each of them with different responsibilities and, usually, working on its own specific subject and not interacting with other actors.

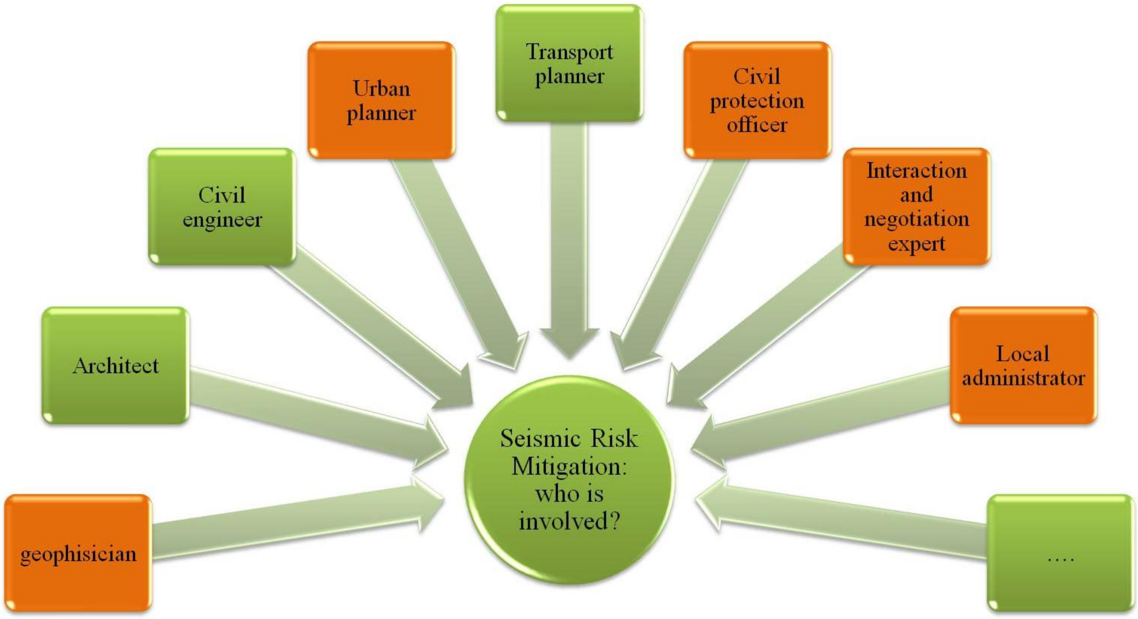

Figure 1: Stakeholders potentially involved. In the orange box, the experts invited to participate during workshop.

The workshop, conceived in a unique session of about four hours, has been organized in three main parts; during the first one, a general framework has been presented to invited experts. In the second one, a discussion about general framework has been carried out: each expert expressed its opinions and gives some interesting issue to develop. The third phase has been individual: each participant was asked to write its own map starting from the general framework above discussed.

The general framework focuses the attention on main elements characterizing seismic risk mitigation problem, as shown in the following map:

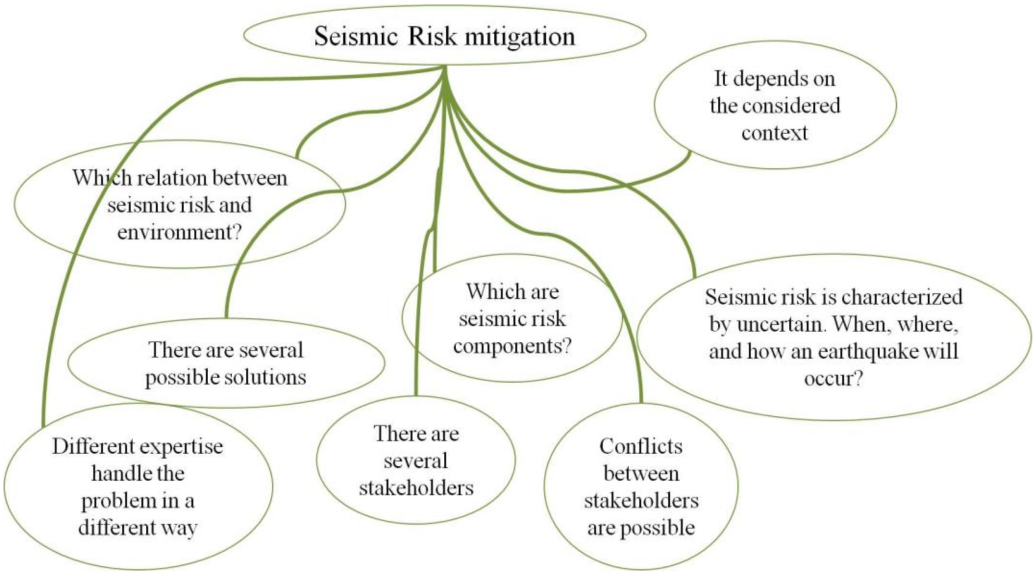

Figure 2: problem positioning

Discussion followed. In this phase, each expert clarified its ideas and discuss with other of their reciprocal position in the context of seismic risk mitigation. In this phase experts interacted in a strong way; each of them asked to speak several times; the feeling, unfortunately, was that they felt the difficulty to compare with different expertise, and finally the asked creativity was not significant: each expert contributed to the discussion, but he continued to stay in its field, without a perspective change.

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In the third phase, each expert was asked to create its own synthetic map, considering the elements on the general framework and evidence emerged during discussion. Workshop unfortunately stopped at the delivery of experts' maps, but research still is on: the collected maps are the basis for the team map obtained, discussed in the next paragraph. Map is not reported because it is very large and moreover it is in Italian language.

6 EVIDENCE FROM THE MAP

The obtained team map presents a high level of complexity. It is composed by more than 200 concepts, with an intricate network of relations, both of causality, connotativity, means-ends. This means that team map highlights some possible contributes to seismic risk mitigation. Through map reading and analysis, the possible contributes to seismic risk mitigation have been grouped in six strategies, referred to different domains, and including a certain number of actions, as schematically represented in the next figure:

Figure 3: groups of strategies identified in the team map

As the scheme proposes, it emerged that the overall objective, the seismic risk mitigation, depends not by the single strategy, but by the global achievement on the overall strategies. Therefore, the map highlights some interrelations between actions of each strategy, indicating the need of harmonization, as mean to produce synergies. The six strategies are briefly described in the following:

(1) Knowledge about hazard: scientific development is strategic. Each progress in the science can produce effects on avoided damages. The consciousness that natural risks cannot be avoided must not stop the research about, because we are persuaded that as much as possible a phenomenon is known, as better we can defend.

(2) Building codes. Resistance of buildings is not enough to resist to the earthquake, but it is true that main effects of earthquake affect structures. It is important improve buildings characteristics. Moreover, it is interesting the new emerging theme of perceived safety. A possible strategy relies on the contribute that private citizens can give to make safer their buildings. At now, a citizen buying a car asks for car safety characteristics, but not so often a citizen, buying an apartment, asks for structural characteristics, taking for granted that it is.

(3) Relation between buildings (that is, vulnerability) and territory (that is, hazard) urban planning. If an area has a high risk, urban plans must avoid settlements, and prefer safer solution, even if they are expensive, and even if this produce conflicts with landowner.

(4) Territorial system functioning. Not only buildings make a city. In each building a function is carried out. There are squares, schools, hospitals, offices, prisons, public spaces etc., and each day people move from

their homes to other places, contributing to a flux. This flux of people and activities must be regulated, in order to optimize the global functioning and avoiding possible collapses.

(5) People at risk. Strong evidence emerged during workshop: seismic risk is not well known. People do not perceive the importance of prevention, nor are conscious that they are exposed to risk. When an earthquake occur, it is perceived as something impossible to contrast, ignoring that prevention is possible, in several ways.

(6) Emergence management. Finally, with the consciousness that seismic risk can be contrasted but not avoided, strategies to manage emergency phase must be defined. Institutions, experts, decision makers and citizens must be prepared to react, each one with its own contribute.

As mentioned, synergies between the six strategies emerged as necessary to reach the objective. If each strategy is strictly separated from the other ones, the global result will be underdeveloped. A global vision is strongly recommended, in order to make effective each strategy, and avoiding a possible negative resonance, but searching to amplify benefits.

Figure 4: photos from workshop with experts

7 CONCLUSIONS: WHERE IS THE RESILIENCE?

Analysis on team map produces an interesting result: in the node represented by resilience concept, a high number of edges enters, making evident that resilience is considered as the property of a territorial system influencing the behavior after a disastrous event. Therefore, as resilience is defined as a property of the whole system, we argued that it can be enhanced working on the whole system, and adopting coherent strategies.

Here is the resilience, in the synergies between strategies, founded in a global approach to the problem. This evidence is as more important, as the workshop highlights that at now experts are not used to work in team, but considering their field as the unique one. During the workshop, each of them continuously tried to defense its position, and only after discussion the need to harmonize single strategies was finally recognized and accepted.

As workshop represents only a test, in conclusion we want to enhance the need of working with involved stakeholders, as SODA approach allows, in order to make them conscious that seismic risk mitigation depends on system resilience, and system resilience can be achieved working on harmonized strategies.

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