In Ensure project we focused our research on the analysis of the vulnerability of territorial systems to the consequences of natural or and na-tech disasters. It becomes therefore very important to better identify and measure in which way and to what extent a territory is exposed to certain types of hazards. Improving the understanding of the factors that make a community vulnerable (or resilient) is therefore crucial.

Here we will go through some key concepts "for the building" of an assessment process as developed by the ENSURE project.

1. The ENSURE project approach underlines three factors in its methodology for assessing vulnerability and resilience: systemic, time and space. What do these mean according to the conceptual and operational framework?

   The reference here is the discussion in file F31 in chapters 1.2.1, 1.2.2, 1.2.3. Notice how the discussion develops from the concept of systemic vulnerability to the relationship among different vulnerabilities and to the time and space working dimensions.

The systemic approach

The Ensure project adopted systemic approach to vulnerability and resilience assessment. Yet it is important to exactly define what "systemic" actually means. The various facets of vulnerability (physical, functional, organisational) and the "types" of vulnerability that can be found in literature (social, economic, territorial) have been explored. The framework was conceived as intrinsically systemic, in that various factors, systems and components concur to create vulnerability and resiliency patterns, both individually and through their multiple connections.

More specifically, the framework adopts a systemic approach at three distinct levels:

- first, the **vulnerability and resilience of systems** is appraised (natural, built environment and social) as it will be further explained.
- second, the term "systemic" has been associated to **vulnerabilities that arise as a consequence of systems interdependency and interconnectedness**;
- third, the question of **how the vulnerability and resilience of different systems interact with one another across temporal and spatial scale** has been addressed.

Relationship among different vulnerabilities

In Ensure project the relationship between different types of vulnerabilities have extensively been analysed and searched: between physical and systemic, between physical, systemic and social, between systemic, social, economic, institutional and territorial. The **various types of vulnerabilities are not separated one from another**, they **actually influence each other**. For example physical vulnerability is often the result of lack of good norms and regulations of the construction sector to build more resistant structures but it may be as well the result of poor inspection capabilities, of lack of compliance with existing rules and norms, no matter how well advanced they may be. Furthermore, the **various types of relationships constitute an integral part of what has been labelled as "territorial" vulnerability, to make clear that the vulnerability of a region, a metropolitan area or an urban centre is much more than just the sum of the vulnerabilities of individual constructions**. It has to do with the way regions, cities and their assets and facilities function, perform and are used by people, agencies and organisations.

Vulnerability in time

With respect to time, several aspects have been considered. First, it was **recognized that vulnerability should be considered as a dynamic rather than static concept**: vulnerabilities **are shaped over time**; **vulnerabilities that we are able to assess today are the result of historic processes**, shaping cities, communities, infrastructures in a way that builds their potential relationship with hazards.

On the other hand, **different types of vulnerabilities become more apparent and relevant at different stages of the disastrous event**:

- **at the impact**, physical vulnerabilities transform into the direct physical damage provoked by the event;
- **during emergency and recovery**, systemic, social, institutional, organisational factors determine how slowly or how fast return to normalcy will be possible and at what conditions (for example with respect to the possibility/capability to reduce or increase pre-event vulnerability).

Vulnerability in space

With respect to space, **two main considerations** constituted the ground for analysis: **on the one hand the relevance of space per se, on the other the concept of scale**.

As for the spatial dimension per se, we may found in literature since long ago, the **distinction between places that are differently affected during the same event**: the so called core of the disaster, its "epicentre", where physical damage is more prominent, and the "periphery" of the event, which is directly and/or indirectly involved in the disaster. In fact, **different types of long distance effects can be considered**: areas from where help will be provided and to where people will be temporarily evacuated in case of need enter into a new type of relationship with the affected areas. New or increased transportation will be required; a flow of goods, services and resources will reinforce and sometime create new linkages.

It would be limiting though to consider only the connections arising for emergency and recovery management purposes: remote areas may be affected by the lack of services, by the interruption of major transportation routes or simply because economic relationships exist with the stricken areas and, some firms will be affected by interruption of activities in the impacted zone.

The fact that different areas from those directly affected by an extreme event must be considered, leads to the need to enlarge the overlook from the "local" scale to larger scales, considering how the "local" is placed within larger economic and administrative regions. **The Ensure project aims at showing that a complex approach is required, because some vulnerabilities are local, or are particularly relevant locally in shaping the damage** (like physical), **but others make sense only when larger scales are considered** (see for example systemic or social, when the latter include administrative and institutional vulnerabilities). The same consideration regarding scales becomes relevant when the natural environment vulnerability is considered.

Furthermore, **some vulnerabilities are actually evident at larger scale because of the nature of the threat and the intrinsic features of systems** (see the Eyjafjallajökull eruption in Iceland in spring 2010, which showed how vulnerable the aviation system is to the consequences of a volcanic explosion provoking ash clouds endangering flights). A rather "local" event, the consequences of which may nevertheless spread over very large zones; an event that has not provoked significant physical damage, losses or victims, but with a very large impact over transportation system and through the ripple effects in economic activities on the entire aviation industry and on the tourist sector.

Finally the scale at which vulnerabilities are relevant depends on the institutional, economic and social arrangements in the different contexts, making clear that a unique rule for deciding a priori at what scales a certain analysis must be conducted does not make particular sense.

The selection of relevant scales will depend on the context, and on the particular way in which different systems are connected and related to each other.

2. Some key elements for vulnerability assessment follow. Can you explain their meaning?

These elements are discussed in many documents but a good synthesis can be found in file F20 in module 2.

- **Complex framework** of vulnerabilities

  The growing complexity of territories, according to some scholars, increases both exposure and vulnerability, producing as effect more frequent and severe disaster. In case of complex events, vulnerabilities depend on intrinsic features of the phenomena themselves, on the consequences of the interactions between hazards and the affected areas and, in many cases, on the lack of an adequate preparedness to such events. The latter induces ineffective interventions that, in turn, may increase vulnerabilities and damages, involving targets not affected by the hazards themselves. Therefore, in these cases, vulnerability assessment has to take into account not only the heterogeneous vulnerabilities due to the different hazard factors at stake and their relationships but, also, the potential effects due to the synergies among different hazard factors and to other factors such as lack of preparedness, not adequate interventions which may, in turn, increase or transfer vulnerabilities from one element to another or even form one area to another.

- Vulnerability of **coupled ecological-human** systems

The case studies related to na-tech events clearly highlight how the complex network of relationships between ecological and human systems may increase the complexity of such events. Modifications on the natural environment induced by human beings determine conditions that influence the trigger of hazards or increase their intensity and effects. Such hazards, mainly in case of na-tech, may induce in turn relevant consequences on the affected environmental systems. Since the latter often represents a key element of local economies, the damages on natural resources reverberate on social and economic systems which are often largely dependent on the integrity of a whole ecosystem rather than on a specific resource.

- **From static to dynamic** vulnerability assessment: the time factor

According to hazard evolution over time (sequences, chains, etc.), different areas and targets can be involved. Each target can be hit by different hazards over time (simultaneously or in a very short time) or the same target can be hit by the same hazard more than once during a given temporal span. Obviously, mainly with respect to physical vulnerability, which is the most hazard-dependent component of vulnerability, the assessment of vulnerability with respect to each hazard does not allow the evaluation of the progressive decrease of the structural efficiency of the exposed elements hit, over time, by the same phenomenon or by different phenomena.

Furthermore, mainly in case of complex events, different aspects of vulnerability (to stress and to losses) arise in different temporal phases. Thus, vulnerability assessment has to take into account the changes over time of the peculiar aspects of vulnerability, the different aspects of vulnerability rising in the different phases of the disaster cycle (sometimes as a consequence of inadequate or wrong interventions carried out in emergency phase) and the changes over time of the relationships among vulnerabilities.Vulnerability assessment: **cross-scale effects**

- Vulnerability assessment: **cross-scale effects**

Complex hazardous events generally induce cross-scale effects which cannot be neglected in vulnerability assessment. For example, multi-site phenomena may affect different points within a wide area: therefore, both detailed vulnerability analyses for each site potentially affected and large scale analyses aimed at analyzing potential relationships among exposed elements and areas will be required. Moreover, in case of chained events (na-na or na-tech), spread phenomena may trigger very localized ones. For example, an earthquake may induce one or more technological accidents which, in turn, will affect a small area surrounding the industrial plant: in this case, vulnerability analyses have to be developed at different scales and potential overlapping among different impacts have to be taken into account.

Furthermore, due to the many interactions among different hazards and different aspects of vulnerability, both internal and external systemic vulnerabilities, which are often related to different spatial scales, become relevant in vulnerability analysis.

- Resilience dimensions in **facing complex disasters**

Most of the mentioned dimensions of resilience (§ 4) are crucial to analyze the capacity of a system to adapt to and recovery from a complex disasters. For example, one of the main problems in case of complex hazardous events is the lack of preparedness both of communities and institutions. Such a lack is generally due to a lack of memory and experience. Since the rareness of such events, indeed, communities and institutions do not develop their capacity to learn from past experience, whereas learning capacity represents a key point for improving resilience and is crucial to build up mitigation measures able, in turn, to effectively reduce vulnerability. Moreover, in case of complex events, the emergency due to the triggering event combined with the effects of the generally unexpected secondary events compete for the few available resources, reducing efficiency and rapidity in response.

Summing up, the main dimensions of resilience are very relevant to a better understanding of the behaviors of the territorial systems hit by complex events.

- Tools for analyzing vulnerabilities **to complex hazardous events**

As clearly arises from some case-studies, it is very difficult to identify main cause-effect relationships among vulnerabilities with respect to complex hazardous events. Thus, a systemic approach to understand vulnerabilities and their relationships is required and conceptual maps seem to fit this purpose. In fact, conceptual maps represent useful tools for exploring the chains of relationships among different vulnerabilities and their development over time and space. Such a tool, even though based on a qualitatively approach, can be very useful both for describing and interpreting past events and for outlining future scenarios.