# PROJECT FINAL REPORT

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## 4.1 Final publishable summary report

## Executive Summary

The ENSURE consortium (http://www.ensureproject.eu/) intended to develop a new methodological framework for Integrated Multi-Scale Vulnerability Assessment.

More precisely, the main achievements during the ENSURE project have been the following:

- To improve the understanding of the articulated nature of the vulnerability concept at different spatial scales, a number of reviews were performed on the concepts and definitions, as well as on the methodologies used to assess vulnerability of structural, territorial, social and economic systems. For these latter, it comes out with a definition that largely follows the majority of definitions in the literature: vulnerability is conceived as “a function of susceptibility to loss and the capacity to recover”. Moreover, the term vulnerability has evolved from a rather negative concept to a concept that relates directly to more positive notions like resilience and adaptive capacity. A differentiation can be made between biophysical and social vulnerability, where the first is directly related to the exposure to a hazard, whereas the latter focuses more on the internal state of a system.
- A review has been performed also to understand how vulnerability was operated in both Natural Hazards (NH) and Climate Change (CC) communities. Its conclusion was that approaches used for assessments in both communities seem to be converging. A particular important contribution to this was the shift from a climate scenario applied to biophysical impacts assessments (first generation) to examining the relationship between current climate variability and current adaptation (second generation) before considering future climate and adaptation in the broad context of environmental stressors, socio-economic change and sustainable development.
- The project has extensively explored the connections between different types of vulnerabilities, namely between: physical and systemic; physical, systemic and social; systemic, social, economic, institutional and territorial. The main objective was to identify key issues that allow recognizing and understanding driving forces in the nature of vulnerability. Although some constant elements could be identified, it was stressed that types and relationships of vulnerability are always to be seen in a wider conceptual framework of inter-linkages to be properly understood. However, it turned out that the contexts of the specific hazards as well as the institutional context are indispensable to understand the vulnerabilities and their linkages. This latter notion is considered crucial in the further operationalization of the vulnerability concept into indicators. Space scale and time are indispensable in the understanding of the various types of vulnerabilities and their linkages.
- A consensus among project partners was achieved regarding the need to make explicit the relevance of resilience and not to restrict to the vulnerability concept only. The main output is that resilience cannot be simply considered as the “flip-side” of vulnerability. Resilience is perhaps an even more dynamic concept than vulnerability, in that it addresses the capacities to innovate and the ability to strategically orient complex processes like those implied by emergency, recovery and reconstruction.
- Processes and catalytic factors of vulnerability change in the course of time and in particular, along a single disaster cycle and its successive stages and/or along successive disaster cycles, have been highlighted. It was recognized that vulnerability should be considered as a dynamic rather than static concept and that 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, organizational 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).
- As for spatial variability, 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. Finally,

transference of vulnerability in space and time should be examined and assessed as coupled processes.

- A new methodological framework was built and tested within a number of case studies. This has permitted to assess vulnerability and resilience across different temporal and spatial scales, acknowledging the different domains where the latter may manifest, and in particular in the natural and the built environment, allocating a large importance to the so called “critical infrastructures”, in social and economic systems. The proposed framework embeds some fundamental theoretical and practical aspects searched for in the previous work packages. It was in particular 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. A set of four matrices, developed for different natural hazards (landslides, floods, earthquakes, forest fires, volcanoes, droughts), has been developed to identify what aspects, relevant parameters and factors should be looked at before the impact (ability or inability to cope with an extreme), at the impact (capacity or not to sustain various types of stresses), just after the impact (ability or not to suffer losses and still continue functioning) and in the longer term of recovery (capacity to find a new state of equilibrium).

## Description of project context and objectives

## ENSURE Background

The assessment of the relation between the occurrence of natural phenomena (hazards) and expected damages (risk) differs considerably from authority to authority and from country to country due to a variety of approaches and methodological concepts. This highlights the difficulty for the implementation of a comprehensive risk analysis, taking properly into account the vulnerability of hazard prone areas.

In literature, the definition of risk as the result of a potential stress on a territorial system (hazard), combined both the value of the possible involved elements (exposure) and their predisposition to damage (vulnerability), is now widely shared. Nevertheless, in common practice very few vulnerability analyses have been carried out both at regional and/or local spatial scale due to a missing general concept and agreement on vulnerability indicators and standardized approaches to estimate and measure vulnerability in relation to natural hazards. In addition, risk analysis depends on the “dimension” of the hazard and on vulnerability analysis, and can therefore be characterized in different terms according to the typology of the hazard and the spatial scale of analysis, e.g. as qualitative indicators (high, medium, low) or quantitative (typology of damage and distribution for a given stock building in a given return period for a given expected magnitude).

Finally, there is an increasing complexity in risk analysis due to the emerging role of Climate Change. This has a twofold implication: i) the influence of Climate Change in spatial and temporal distribution of weather-related extreme events ii) the rising awareness about Climate Change as a hazard that was never experienced before both in terms of scientific methodology as well as practical application in risk assessment.

In order to address this complex situation it is necessary to improve:

- the knowledge on physical damages vs. natural hazards, especially on those where vulnerability assessment is still poorly developed for a series of exposed elements (*physical vulnerability*);
- the knowledge on social and economic losses vs. natural hazards, currently fairly investigated (*socio-economic vulnerability*);
- the capability of the European society to cope with hazards (*systemic vulnerability, resilience*);
- the interrelations among different types of vulnerabilities *(integrated vulnerability)*.

As a matter of fact, vulnerability, as a key concept in disaster literature, has already been pointed out long ago for its importance. Nevertheless, the majority of studies and grants have been devoted to hazard related research, neglecting the influence of vulnerability of exposed systems on the death toll and losses in case of natural or man-made disasters. The basic assumption of the following proposal "Enhancing resilience of communities and territories facing natural and na-tech hazards" is that our ability to understand and evaluate better different types of vulnerabilities constitutes a crucial tool to strengthen communities in the face of disasters due to extreme events and climate change. Improving the understanding of the factors that makes a community more vulnerable, addressing the various physical, psychological, cultural, and systemic social and economic components that shape the relationship between societies and "natural" environment, will permit more tailored and articulated mitigation measures.

Starting from the consideration of affected communities provides the conceptual justification for considering apparently different fields of study, such as those related to hydro-geological, seismic and volcanic risk as well as climate change. From the perspective of settled communities, in fact, they are not distinct sectors, but the reality of areas that may be threatened by several phenomena at the same time. Such a condition is less an exception than traditionally thought of (see Dilley et al, 2005). Being able to address those in a multi-risk perspective is essential, in order to avoid lack of coherence between mitigation efforts designed separately without consideration of potential enchained or overlapping effects. Furthermore it is crucial to recognize to what extent community resilience can be dynamically developed in the face of a variety of stressors avoiding as far as possible waste of resources as well as conflicting outcomes.

Vulnerability is the key concept since any vulnerability assessment allows comparing regional entities or sectors. Such assessments close the gaps between impact analysis and necessary adaptation strategies by identifying the hot spots for action. Experiences show that this can help decision makers to implement strategic actions (cf. Kropp et al. 2006).

## Project objectives

Considering the above described background, the ***overall objective of ENSURE*** was to develop a new methodological framework for an Integrated Multi-Scale Vulnerability Assessment, based on a comprehensive, integrated and inter-disciplinary understanding of how mitigation strategies can be improved in the future, in order to reduce human losses, economic damage and social discomfort due to extreme events striking communities exposed to a variety of natural hazards as well as to the potential consequences of Climate Change.

More precisely, the following main objectives were planned to be achieved:

- To improve the understanding of the articulated nature of the vulnerability concept (physical, economic, cultural, social and systemic), at different spatial scales (regional and local), comparing definitions that have been proposed by different scholars and research communities (particularly by the "disasters" and "climate change" communities which will lead to an improvement of the integration of the vulnerability concepts of the disaster risk community (sustainable mitigation) with those of the climate change community (adaptation strategies) as long demanded by many scientist and practitioners, in order to strengthen progress towards sustainable development);
- To analyze the relationship between the vulnerability concept and other notions that are common in the disaster and climate change arenas, such as "risk", "damage", "exposure", "resilience" and "adaptation";
- To develop integration and connection of vulnerability types identifying key issues that allow recognizing and understanding the driving forces in the nature of vulnerability (dynamical vulnerability);
- To investigate the temporal and spatial variability of the relation between different types of vulnerability and different types of damage, as basic assumption for future scenarios;

- To propose new and improve existing vulnerability assessment models and parameters, specifying procedures to make them operable within a given territorial or cultural context, so as to assess the vulnerability of a given community to a variety of extremes;
- To develop a comprehensive and structured method that integrates the assessment of different types of vulnerabilities to be tested in three specific case studies at two main scales: local scale and regional context, integrating physical, psychological, cultural, social and economic perspectives;
- To establish improved risk scenarios, based on a new methodological framework considering properly the new vulnerability indicators for different exposed elements, at different geographical spatial scales.

With respect to the above mentioned objectives, the tasks executed during the project (excepted management activities) have been the following:

1. **State-of-the-art on vulnerability types (WP1):** first, a review was performed on the vulnerability concepts and definitions, as well as on the methodologies used to assess vulnerability of structural, territorial, social and economic systems. Then, the vulnerability concepts used in the field of natural hazards were compared to those used in climate change analyses. Finally, vulnerability was explored through an "integral" perspective, in an attempt to identify key factors that can affect vulnerability, in order to account not only for the physical reality and systemic aspects, but also for the human "interiors" (psychology, culture and collective value).
2. **Integration and connection of Vulnerabilities (WP2):** first, connections between the various types of vulnerability (social with economic; systemic with structural; social and economic with physical) were investigated, in order to identify key issues that allow recognizing and understanding driving forces in the nature of vulnerability. Second, we analyzed to what extent systemic and social, economic vulnerabilities can be considered common to a variety of threats and to what extent they are linked to specific hazards.
3. **Vulnerabilities in time and space (WP3):** in this WP, we analyzed the multiple facets of vulnerability, which are determined by: (a) the type of hazard under examination; (b) the type of the agency / structure carrying vulnerability; (c) the period of concern; (d) the type of losses / damages of reference; (e) the geographical position / range / scale of both the potential disaster event and the agency / structure affected.
4. **Development of a new methodological framework for an Integrated Multi-Scale Vulnerability Assessment (WP4):** an iterative process was carried out to develop a methodological matrix-like framework, in order to assess communities' vulnerability and resilience at regional and local levels and across different temporal scales, considering the main fields recognized as relevant in previous WPs (structures, territorial systems, including natural, social and economic systems), as well as the most fundamental links among them.
5. **Application of an integrated vulnerability conceptual approach (WP5):** first, the data relevant for analyses were collected and prepared. Then, the methodological framework developed in WP4 for an integrated vulnerability assessment, was implemented and tested on selected case study areas.
6. **Dissemination, communication and evaluation of impacts (WP6):** the activities here were conform with those planned in the program: (i) elaboration of an awareness and dissemination strategy, providing a brief but concise guidance to the partners on how scientific results will be communicated throughout the time frame of the ENSURE project; (ii) launching of the ENSURE public website; (iii) elaboration of branding and marketing material, including the development of a logo, an ENSURE identity handbook, presentation layout and contents and brochures, (iv) publications (international conferences, scientific journals) and other dissemination activities (e.g. attending relevant events and final

workshop organization); (v) development of an e-learning tool and (vi) monitoring / evaluation of impact.

## Scientific & Technological Results/Foregrounds

## State-of-the-art on vulnerability of structural, territorial and socio-economic systems:

### *Structural systems (Del1.1.1)*

The review on the existing concepts and methodologies for vulnerability assessment of structural systems, related to different natural hazards (earthquakes, floods, landslides and volcanoes) within a given territory, has permitted to highlight common grounds and main differences existing between the various practices, as well as possible gaps to be filled in each field.

For the reviewed hazard-specific practices, risk is essentially defined as the product of (UNDRO, 1979; Dilley et al., 2005): (i) hazard, which is the probability of occurrence of a particular natural event; (ii) exposure, which represents the global "value" of elements at risk in a given territorial system (buildings, infrastructures, people, …); (iii) vulnerability, which represents the degree of loss/potential damage/fragility of a particular element or set of elements at risk, within the area affected by the hazardous event characterized by a given intensity or level. In this case, vulnerability is related to the physical interactions between the potentially damaging event and the vulnerable elements of the physical environment. It is defined on a scale ranging from 0 (no loss/damage) to 1 (total loss/damage) and is also strongly dependent on resolution scale for analysis.

Although being hazard-specific, practices for structural vulnerability assessment generally follow the same procedure for analysis:

1. Hazard evaluation, to (i) quantify the probability of occurrence of the hazardous event (e.g. return periods) and (ii) estimate the intensity and the typology of the physical stresses/actions that will be sustained by affected structures within the territory, in case of event occurrence (e.g. hydrodynamic actions in case of flooding, actions resulting from ground shaking or settlements, etc.).
2. Estimation of the exposed elements, classified according to a typology grouping set of exposed elements according to the peculiar features affecting their structural behavior and response to the possible physical impacts and stresses. Exposure may also englobe indicators representative of the worth (monetary value) for the elements at risk. In the case of cultural heritage, the notion of importance is also used, which represents the capability of each element to represent the historical/cultural identity of a given typology in the study area.
3. Definition/determination of physical vulnerability models, defined either on the basis of statistical processing of damage observations (with or without including the expert judgments) and expert opinion, or on the basis of analytical/simplified-mechanical models. Depending on the spatial scale or resolution for analysis, the methodology consists in attributing a vulnerability indicator (e.g. vulnerability index, fragility function) to a single element (building, etc.) or to the whole group of elements either uniformly or randomly in this case. Vulnerability assessment by fragility functions, which relate the probability to reach or exceed a certain degree of loss/damage to the force exerted by the relevant indicator(s) of physical aggression, is common.

Due to the variety of potential threats, according to varying levels of intensity, location and time of occurrence for hazards considered, the definition of the relevant indicator(s) for physical aggression is a main challenging issue when assessing vulnerability through fragility functions. What is to be noted here is that most assessment methodologies use a poor definition of the actual aggression (hazard represented by very few parameters, generally one), leading to strong uncertainties and to inadequacy of vulnerability curves.

Moreover, the incorporation of vulnerability within risk assessment is not developed at the same level for all the reviewed hazards: contrary to earthquake risk assessment, quantitative estimations are not often made in practice for a number of natural perils (e.g. mass movements, volcanoes), where fragility curves are rarely or not used. Physical vulnerability is poorly modeled in this case, for a number of reasons that are essentially related to the nature of the peril itself and to the fact that the benefits of considering an element's vulnerability may be considered as limited. Some of the main reasons we can list:

- human casualties caused by the event itself rather than by building damages;
- lack of observational data (e.g. hazard, elements at risk, induced damages);
- variety of possible processes involved in one hazardous event and complexity of related structural damage mechanisms leading to difficult quantitative assessment;
- buildings exposed to the full force of the event are generally not repairable (e.g. pyroclastic flows, mass movements): in this case, fragility reduces to one constant equal to unity for all non-zero values of the hazard parameter(s);
- possibility to reduce the level of exposure by adapted measures (e.g. efficient land-use planning, engineering works, evacuation), due to the scale (time/space) of the hazardous event. There is less incentive to assess vulnerability, when forecasting (e.g. monitoring) and prevention are possible.

***Territorial systems (Del1.1.2)***

The meaning of territorial vulnerability reflects propensity to losses of complex geographical entities (physical, social, economic, cultural, organizational, institutional micro-units and macro-structures) due to a stressor, including also for the Climate Change (CC) community, the generation of exposures and new hazards by these entities.

Territorial vulnerability denotes susceptibility to losses of all these units and structures contained in a territorial entity as well as of their interconnections and linkages. Kindred terms are "geographical vulnerability", "urban vulnerability", vulnerability of an area, region etc. Some researchers emphasize the "exposure" dimension of territorial vulnerability, others consider equally the "exposure" and "coping capacity" dimensions and there is a third group advocating a three dimensional essence of vulnerability (i.e. one comprising "exposure", "sensitivity" and "adaptive capacity" or "exposure", "resistance" and "resilience"). As to the locus and origin of Territorial Vulnerability, the exposure component is considered as an external factor while other components (i.e. coping capacity, sensitivity and adaptive capacity, resistance and resilience) are considered internal or inherent to the territory / community factors of vulnerability.

Different procedures of territorial vulnerability assessment exist: some assessment methodologies start from consideration of vulnerability of the micro-units included in a territory (without ignoring the influence of the wider structures) and upscale then step by step to larger units. Others start from macro-structures and macro-indicators and attempt subsequently indicator specializations and division of the territory to lower scale units. Approaches may be hazard specific (e.g. methodology for floods, the CIPE-MURST methodology, etc.), or referring to groups of hazards (e.g. Munich Re and DRI approaches) or hazard-independent (e.g. ESPON Hazard methodology, ARMONIA etc.).

The methodologies for assessment differ in terms of their stance as regards to the type(s) of losses to which vulnerability refers. In some cases the referred type of loss is explicitly quoted; in others it is implicitly derived; finally there is a third group of methodologies where reference to the loss type is not made at all, implying that the suggested methodology covers all forms of impacts and losses (direct and indirect, primary and secondary, loss of lives, physical damages, economic losses, property losses, disruption of services, operations and processes, bankruptcy or dislocation of firms, business closures and so on).

The results of the performed review show that most approaches do not deal with the root causes of vulnerability, the mechanisms and processes that make a spatial entity (a geographical or territorial unit) vulnerable, but deal instead with the end results, the observable symptoms of vulnerability.

Moreover, although they acknowledge that vulnerability of spatial units is multidimensional (social, economic, functional, systemic and physical dimensions), practical assessment is generally partial and the end-result is almost exclusively "physically-oriented" and dependent on land-use parameters.

Finally, almost all methodologies, except those focusing on causal origins and the transference mechanisms of vulnerability, are based on procedures and parameters that yield mappable results (spatial distribution of vulnerability to support spatially differentiated measures and policies), which are more or less settled and steady in temporal terms. This rationale presupposes that vulnerability fluctuates in terms of space and leads to neglecting the temporal nature of vulnerability, as well as the immaterial aspects of vulnerability (e.g. institutional), that might affect the material ones or be affected by them, but are a non-spatial property. For instance, pre-disaster exposure is a mappable condition, but resilience (if considered as another component of vulnerability) is a matter of immaterial assets and intimately connected with organizational issues and in this sense, it is a non-spatial property. Moreover, vulnerability is not assessed as a time variant parameter, whereas at least in post-disaster periods, it has to do with dynamic action and movement and undergoes constant changes. First instant losses (due to pre-disaster vulnerabilities) are generally followed by waves of coping efforts which may manage short term recovery but lead the temporarily recovered entities into deteriorated vulnerability conditions in the long term. Coping capacity is not always a factor relieving vulnerability and in any case the latter is a time variant parameter.

An additional review of the territorial capital concept, which is useful for the study of regional development, has been performed as well, in order to find possible connection with territorial vulnerability, as the potential of bringing both concepts closer together, may help to better understand vulnerability: the territorial capital of an area may be considered as a critical factor for determining territorial vulnerability. Moreover, both concepts share common features:

- they are multidimensional and complex;
- they essentially describe an area unit's potential or lack of it to face a challenge, either the area's future development and sustainability or its capacity to withstand shocks and stresses.

In order to further enhance possible correlations between elements of vulnerability and of territorial capital, a table was proposed (see Del.1.1.2-3), which groups the elements of vulnerability and territorial capital into 5 categories: economic, social, natural, manmade - physical and institutional. The elements (skills, knowledge, health, human energy, networks, groups, institutions, infrastructure, technology, equipment, savings, credit, natural resources, land, water, fauna and flora) which make up the five forms of capital (human, social, physical, financial and natural) used in one of the territorial vulnerability models proposed by Wisner *et al*. (2004) are all typical features of territorial capital. Although not exhaustive, this table already shows interesting conceptual bridges, which indicate that the analysis of territorial capital may become a useful tool for territorial vulnerability assessment.

### *Socio-economic systems (Del1.1.3)*

The review for definitions and approaches to analyze vulnerability and vulnerability of socio-economic systems in particular, reveals that definitions vary between disciplines, hazard types and analytical contexts. Neither multidisciplinary literature on disaster nor risk management has developed a widely accepted definition of vulnerability. As an alternative, often taxonomies of vulnerability are proposed, which are, however, less useful to arrive at a comprehensive and integrated understanding of vulnerability.

The lack of consensus makes it almost impossible and even undesirable to conclude with one final vulnerability definition. On the other hand the adoption of a relativistic approach in the definition of

vulnerability would not be very constructive for the further development of methodologies to assess vulnerability. In addition, a kind of evolution of the concept could be sketched and links with other related concepts be identified:

- A differentiation can be made between biophysical and social vulnerability, where the first is directly related to the exposure to a hazard, whereas the latter focuses more on the internal state of a system.
- The stage of exclusive focus on the physical environment and ignorance or over-simplification of the socio-economic environment has largely come to an end.
- The review comes out with a definition that largely follows the majority of definitions in the social, economic and institutional literature: vulnerability is conceived as “a function of susceptibility to loss and the capacity to recover”.
- The term vulnerability has evolved from a rather negative concept to a concept that relates directly to more positive notions like resilience and adaptive capacity.
- The traditional interpretation of vulnerability as the reciprocal of resilience is more and more challenged and replaced by notions seeing resilience as an integral component of vulnerability or considering vulnerability as the static and resilience as the dynamic propensity of a system.
- Psychological elements like risk perception, awareness and personal and collective coping mechanisms are crucial elements to be considered in any vulnerability assessment.
- The intrinsic relationship of vulnerability with terms such as resilience and adaptive capacity has emphasized more and more the need for the consideration of dynamic elements, including elements of learning, in the application of the vulnerability concept.

The result is that regarding the vulnerability assessment for socio-economic systems, a clear distinction should be made between economic vulnerability and social vulnerability assessment, which are two related but distinct fields of analysis.

The methods of economic vulnerability assessment are closely linked with damage assessment methodologies and therefore experiences in the field of the latter are relevant for vulnerability assessment. Methodological issues that are relevant for economic assessment are: the private versus the public and societal perspective; the scale and level of analysis; stock versus flow estimation; estimation of direct and indirect damage; and the valuation of tangible and intangible losses. Although economic assessment methodologies still differ in specific elements between thematic (hazard-wise) and geographical areas, one could observe presently more or less standardized approaches to measure damages. Finally one could observe a transition from economic and purely financial damage loss assessment to the assessment of the vulnerability of economic systems.

Social vulnerability assessment related to hazards often focuses on the understanding of the social environment that transforms a natural hazard into a disaster, where the cause is often seen as mainly social and the consequences differ between social groups. Methodologies to assess social vulnerability are not necessarily specific and include typical social science approaches, like qualitative and participatory methodologies. Key in these approaches is the recognition of the specific contexts in which the vulnerability is being assessed. Risk perception and local coping mechanisms are some examples of specific elements that are addressed as part of social vulnerability assessment. Integrating the outputs of social vulnerability assessment with the outcome of more physical assessment remains difficult. In addition, a number of relevant indicator initiatives have been identified that intend to measure vulnerability in its different dimensions. Approaches vary from deductive to more inductive approaches. Whatever the approach, crucial remains the application of a systematic and transparent approach in the development of indicators, including a good conceptual understanding of vulnerability in the specific context.

Finally, the availability of up-to-date data remains crucial for any relevant assessment of vulnerability.

Despite the absence of an unequivocal definition of vulnerability, we can conclude that a number of perspectives and methodological approaches from the social and economic sciences provide indispensable contributions to vulnerability assessment in an integrated manner.

## Comparison of vulnerability concepts used in natural hazards to those used in climate change analyses (Del1.2)

The proposed review and case study analyses have permitted to understand how vulnerability was operated in both Natural Hazards (NH) and Climate Change (CC) communities.

The review shows that operating similarities in concepts that shared different names can be found, but the opposite case is also observed, with similar notions mentioned by both communities but with a rather different level of practical implementation.

For instance, the concepts of “susceptibility” and “sensitivity” used respectively by the NH and CC communities are in fact closely related and therefore the difference in this case lays almost exclusively on semantic. These terms both reflect the characteristics of a particular system that make it prone to impacts by a particular stimulus.

On the contrary, although the coping capacity concept used in the NH sphere and the adaptive capacity one used in CC share some similarities, the reviewed case studies show that they are hard to operate in the practical work carried out by both communities. However, contrary to the coping capacity, adaptive capacity is present in the definition of vulnerability and seems to be more operated in the CC community.

In addition, the review points out the following:

- In the NH case studies related to vulnerability assessment to floods, the concepts used and the parameters employed are the traditional ones of economic flood damage potential. On the contrary, the analyzed vulnerability studies carried out within the CC context hardly incorporate any economic valuation of damages. Moreover, there is an increasing effort to incorporate a social dimension in the NH assessments, since it has been highlighted as an important factor in recent floods. The social system is however represented in a very superficial way for the cases analyzed in this review.
- The use of models and scenarios for different time steps is a very pronounced characteristic of vulnerability assessments in CC. The models used are both socio-economic and climatic in order to test climate impacts under certain policy and development assumptions.
- The final aim of vulnerability studies carried out by the CC community is generally to implement adaptation measures in order to reduce the vulnerability of the system. Being highly interdisciplinary, CC vulnerability studies tend to focus on a constellation of hazards that may affect the system. It is therefore common to find measures of vulnerability to floods, droughts, heat haves, sea level rise, agriculture or tourism in the same assessment. The approach at a regional scale is strongly sector oriented while the overarching element for vulnerability assessment is the climatic system. On the contrary, the focus of the NH community is more frequently put on the assessment and reduction of the risk of a system to a particular hazard and also, with increasingly trends in the community, looking on how to increase the resilience of the system. Usually, NH community deals with the risk due to one specific hazard (although multi hazards vulnerability/ risk assessments can also be found) and its implications across several sectors. In order to reduce the risk some options/decisions will have to be made and the consequent risk reduction is evaluated usually in terms of monetary losses avoided.

In conclusion, approaches of vulnerability assessments for both communities seem to be converging. A particular important contribution to this was the shift from a climate scenario applied to biophysical impacts assessments (first generation) to examining the relationship between current

climate variability and current adaptation (second generation) before considering future climate and adaptation in the broad context of environmental stressors, socio-economic change and sustainable development.

However, how to develop an overarching definition of vulnerability that could be shared among different disciplines and how to structure vulnerability assessments so that their findings are comparable and generalizations can be made, seem to remain as fundamental challenges for both communities. Moreover, vulnerability assessments should stress significant human-environment relations as a coupled system, one that can be an endogenous source of stress by itself; this means that its own dynamics can be a source of future vulnerability. Finally, we should also consider the multiple scales (space, time) of vulnerability processes.

## An integral framework analysis for vulnerability (Del1.3)

An attempt has been made to explore vulnerability through an "integral" perspective, in order to identify key factors that can affect vulnerability and in order to highlight the influence of intangible aspects of vulnerability on tangible and material aspects.

The Integral theory by itself, which has been developed in the last 30 years, aims at providing a systematic integration of all knowledge. The integral framework proposed by philosopher Ken Wilber is a quite complex approach, grounded on two main models: AQUAL (All quadrants-all levels) and the Spiral Dynamic. In the ENSURE project, the AQAL model has been taken into account and, a deepening on the Four Quadrants (4Q) scheme has been carried out, in which every phenomenon is analyzed under four lenses that are the interior-individual, the interior-collective, the exterior-individual and the exterior-collective perspectives. They represent four distinct ways to look at any reality. The 4Q scheme of the integral framework provides a way to account not only for the physical reality and systemic aspects, but also for the immaterial aspects or human "interiors" (psychology, culture and collective value).

Having filtered the vulnerability issue through the interior/exterior and individual/collective dimensions, it is worth providing some comments about the limits and the opportunities showed by the application of the 4Q framework. Criticism raised about the 4Q approach is related mainly to two points:

1. the operability in terms of defining parameters for the assessment of different types of vulnerability;
2. the inability to catch the dynamic aspects (time and space) of vulnerability : further investigations by the integral theory practitioners might allow including these aspects in the approach.

However, a positive point about the 4Q is that it is "an interesting way to think about a problem", especially from the "individual" and the "collective" point of views. As a taxonomic tool, it represents a starting point to carry out elaborations on linkages among different aspects of vulnerability and to understand, as an example, interactions between social and physical layers.

In conclusion, the 4Q scheme can be assimilated to a summary table of key factors affecting vulnerability both in an increasing and in a reducing manner. This kind of arrangement, even if it appears divergent from well-accepted schools of thought grounding on the issue at stake, has allowed highlighting linkages connecting some immaterial aspects, as the psychological and cultural ones, with more evident aspects related to the behavior and the physical environment. By doing so, the 4Q framework has shown its ability in terms of tool of analysis of a given phenomenon. Some limits of the approach have arisen, as well, in respect to the representation of the variability of vulnerability depending on time and space. An analyses of the obtained results, seems to show that an "integral" theory addressed to the inclusion of everything, risks not to be careful of the various nature of problems and of different peculiarities existing among hazards. Moreover, it is not prone to provide operational indicators to assess and monitoring vulnerability. Nevertheless, the core concept which the AQAL model stems from, namely a spread negligence towards the importance of interior aspects as responsible of actions and physical results, is preserved and validated.

## Relationships among different vulnerabilities (Del2.1.1, Del2.1.2, Del2.1.3, Del2.2)

Work performed in WP2 permitted to extensively analyse and search for the relationship between different types of vulnerabilities: between physical and systemic, between physical, systemic and social, between systemic, social, economic, institutional and territorial. The main objective was to explore the connections between these various types of vulnerability in order to identify key issues that allow recognizing and understanding driving forces in the nature of vulnerability. In this way it was assumed that the dynamic and evolutionary components of settlements, communities and their relationships could be better understood.

In addition, it was analyzed to what extent systemic and social, economic vulnerability could be considered common to a variety of threats and to what extent they are linked to specific hazards. In this way the possible treatment of these vulnerabilities in multi-risk approaches could be explored.

The main result is a detailed and comprehensive systematization of the various vulnerability concepts which provide a basis for the further operationalization and subsequent approaches for vulnerability assessment.

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.

At the conceptual level, a number of ideas and conceptions on types and relationships of vulnerability have been clarified. Use was made of extensive literature review and the analysis of a wide range of case studies from different institutional, physical and societal contexts. The meaning and semantic implications of basic terms related to the vulnerability concept have been explored and further detailed. Examples of such terms include: systemic vulnerability, external and internal systemic vulnerability, vulnerability to stress and to losses, exposure, coping or response capacity, resilience and various types of vulnerability like economic, social, and physical vulnerability, including ecological and institutional vulnerability.

Although some constant elements could be identified (see below), it was stressed that types and relationships of vulnerability are always to be seen in a wider conceptual framework of inter-linkages to be properly understood. However, it turned out that the contexts of the specific hazards as well as the institutional context are indispensable to understand the vulnerabilities and their linkages. This latter notion is considered crucial in the further operationalization of the vulnerability concept into indicators. Space, scale and time are indispensable in the understanding of the various types of vulnerabilities and their linkages. Trade-offs (within space; between scales; and over time) between different types of vulnerability are an important notion identified in a number of case studies.

Other key findings at the conceptual level include:

- Factors contributing to the various types of vulnerability should be clearly distinguished from the vulnerability itself as well as from the consequences of vulnerability.
- Different types of vulnerability (e.g. social and economic) are strongly linked and sometimes difficult to unravel; however, the disciplinary and often asymmetrical development of the conceptualizations of the different vulnerabilities types complicates a fully consistent integration. Diagrams and visualizations are very helpful in depicting these interrelationships.

To conclude, the various types of relationship are part of a more general and integrated vulnerability that of the built environment, where different aspects, social, institutional, economic and physical interact as do the different systems and subsystems that they characterize as far as their relative lack of resistance to natural extremes is concerned. Such a complex interaction and interplay of vulnerability types has been labeled as “territorial” vulnerability, to make clear that the vulnerability of a region, a metropolitan area or an urban center 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 organizations.

At the more substantial level, a conclusion is that the specific context plays a crucial role in the understanding of the relationship between the various types of vulnerability. However, a number of constant elements can be identified, such as:

- The presence and relevance of cycles of 'influence-feedback-influence', and feedback loops which propagate increased or decreased vulnerabilities over time.
- Economic vulnerability seems to exert a greater influence on social vulnerability than vice versa.
- The exploration of the relationship between social and economic vulnerability in relation to physical vulnerability revealed a number of social, economic, institutional and political factors that exert influence on the physical vulnerability. These factors (e.g. Perception and communication turned out be critical factors) are crucial to be considered in relating the physical environment and the surrounding social, economic, cultural and institutional elements.

Methodologies for integrating vulnerabilities, among others by means of indicators and indices, have been identified; but no single one suggested and adopted yet; giving the specific contexts in which these vulnerabilities are to be analyzed. However, a number of general principles for setting up a methodological framework for integrated vulnerability assessment have been provided. Any integrated assessment of vulnerabilities has to:

- be flexible, in order to allow procedures and indicators according to the different aims, contexts and scales of the assessment;
- look at vulnerability as a whole, taking into account its multiple facets and the mutual relationships among them;
- couple qualitative and quantitative approaches in order to provide a variety of inputs flexible to different aims and able to support different policies;
- be based on hazard analyses which take into account the different hazards which potentially threaten a given territory, the evolution paths of such hazards, including the potential synergies and chains among them;
- take into account that vulnerabilities and the relationships among them constantly change over time and in space and that different facets of vulnerability raise at different stages of the disaster cycle;
- be based on multi-scale and cross-scale analyses;
- take into account resilience dimensions;
- provide innovative tools for understanding and assessing vulnerabilities and for communicating the outcomes of such a work to other experts, to decision makers and to communities.

Finally, the framework should allow for an iterative and flexible process taking into account the uncertainties and limited knowledge; allowing to learn over time.

## Vulnerability and resilience: integration of vulnerabilities vs. Natural and Na-tech Hazards (Del2.2)

Initially, in the ENSURE project, vulnerability was the main topic to be searched for, with little consideration of other definitions. Nevertheless during the project development, a consensus among partners was achieved regarding the need to make explicit the relevance of resilience. Vulnerability and resilience can be interpreted as two separate but interrelated concepts and are valuable to understand from two different perspectives the complex systems which are potentially subject to an external stress.

The main output is that resilience cannot be simply considered as the “flip-side” of vulnerability. In other terms, a resilient community is not just a community manifesting low levels of vulnerability. Also because what seems to emerge in literature is a different focus of vulnerability and resilience studies: the first are more oriented towards the identification of weaknesses, fragilities that make a given territory, a given community, a given country unable to resist the stress provoked by an “external” source. Looking at resilience, we appreciate the capacities to react, to overcome the problems created by the same existence of vulnerabilities and to “bounce back” despite damages and disruption to ordinary life. Resilience entails the capacity to recover effectively, transforming the damage and losses into opportunities for a different territorial and environmental setting, in such a way that pre-event vulnerabilities will be reduced and the resulting societal, urban, and regional patterns are healthier and safer than before the event impact. Authors like Handmer and Dovers, (1997), Norris and co-workers (Norris et al., 2008), have rejected the idea that a resilient community or a resilient city is simply a community or a city that is able to bounce back to pre-event conditions. Sometimes getting back to the exact pre-event conditions is just the opposite of resilience, particularly when high level of vulnerabilities characterized that condition. Instead, resilience has to do with the capacity to adapt to changes, to manage creatively uncertainty, to find resources, both material and immaterial, to face the consequences of a disaster.

Resilience is perhaps an even more dynamic concept than vulnerability, in that it addresses the capacities to innovate and the ability to strategically orient complex processes like those implied by emergency, recovery and reconstruction.

As just mentioned, literature on resilience is as vast as that on vulnerability. Also in this case, the ENSURE project needed to choose a direction of work, an interpretation cutting across the various definitions and alternative views available so as to be able to include resilience in the integrated framework.

The diagram in figure 1 represents the interpretation provided by the project.

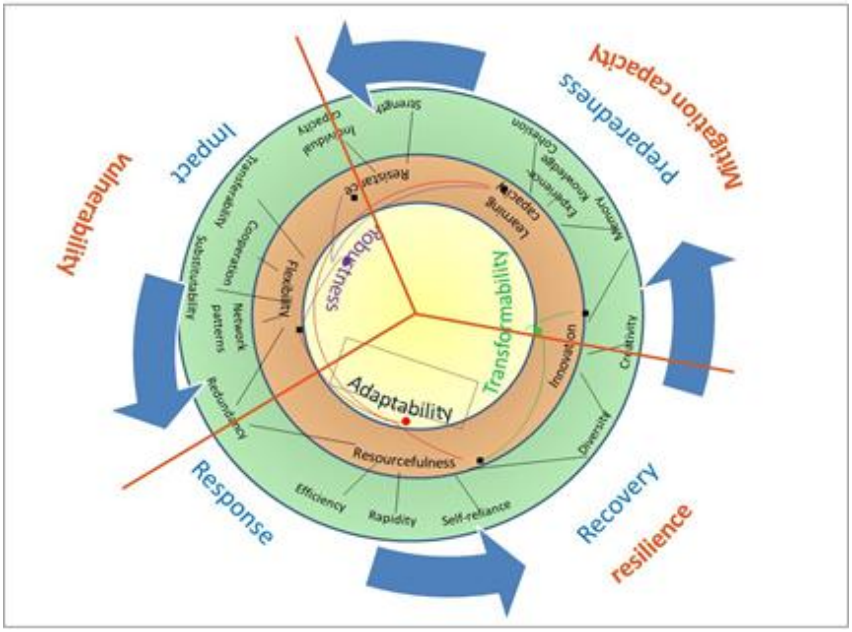


*Figure 1: Diagram showing the conceptualization of vulnerability, mitigation capacity and resilience in the ENSURE project*

## Vulnerabilities in time and space (Del3.1, Del3.2)

The fact that vulnerability holds relevant temporal and spatial dimensions is well recognized in literature (while it may be stated that the relationship among different types of vulnerabilities described in WP2 even though well documented has not been at the core of most investigations on vulnerability until now).

With respect to time, several aspects have been considered, and processes and catalytic factors of vulnerability change in the course of time and in particular, along a single disaster cycle and its successive stages and/or along successive disaster cycles, have been highlighted.

Two alternative approaches have been used: 1) the “Vulnerability Facets” (VF) approach using “vulnerability to stress” and “vulnerability to loss” as key terms and searching for interactions among them, and 2) the “Vulnerability Actor” (VA) approach (rooted in political economy of disasters but validated also by the systemic point of view), using “vulnerability actor” performing “resilience functions” as key terms.

Important findings from the VF approach are:

a) only physical and ecological vulnerability are cases of vulnerability to stress, all the rest (economic, social, institutional, territorial) are cases of vulnerability to loss;

b) vulnerability to stress is a function of hazard characteristics;

c) vulnerability to loss is a function of vulnerability to stress and the respective thresholds of losses.

From the perspective of the VA approach, equally important outcomes about the causal origin and the actual processes of vulnerability change are: (a) a VA, as a vulnerability managing system, attempts to get rid of this undesirable property and influences (and is influenced by), directly or indirectly, other Actors’ vulnerability; (b) a VA may target simultaneously vulnerability to several potential threats and/or multiple types of losses and may at the same time carry several vulnerability facets; (c) a VA performs specific “functions” which can be recognized as resilience: (i) internal (re)balancing of own vulnerability facets, meaning control and restriction of certain facets leaving others to deteriorate; (ii) transformation/transfer of certain vulnerability facets to other actors; (iii) (re)distribution to the disaster cycle stages (current and future) and (re)balancing between exposure and response capacity; (iv) (re)distribution between current and future hazards; (v) receiving vulnerability from other Actors.

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, organizational 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).

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 find 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 “epicenter”, 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 impact 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. Some authors have stated that vulnerability assessment is inevitably local. The ENSURE project aims at challenging such position by showing that a more 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. The Eyjafjallajökull eruption in Iceland in spring 2010 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.

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.

Finally, transference of vulnerability in space and time should be examined and assessed as coupled processes. The transformation and transference mechanisms and processes imply two preconditions for proper vulnerability assessment: (1) vulnerability assessment has to be performed at an appropriately large geographical scale depending both on the potential for vulnerability transference over space; (2) there is a need for a rolling process of vulnerability assessment.

## A new methodological framework for an Integrated Multi-Scale Vulnerability Assessment

The main goal of WP4 was to provide a more comprehensive and structured tool to assess communities' vulnerabilities at regional and local level looking at the three main fields that have been recognized as relevant in previous WPs (structures, territorial systems, including natural, social and economic systems) and considering the most fundamental links among them.
The general objective was therefore to develop such a tool integrating as much as possible parameters and vulnerability factors that have been already codified in literature and analyzed in WP1, as well as new parameters and vulnerability assessment tools identified by partners and to be integrated in the model in such a way that the links among vulnerabilities (recognized in WP2) are treated and managed. Therefore a sort of matrix-like framework had to be developed as to represent at best the interrelations mentioned above.

### *Methodology description*

The integrated framework required an iterative process of development. The resulting deliverable illustrates the methodological framework to assess vulnerability and resilience across different temporal and spatial scales, acknowledging the different domains where the latter may manifest, and in particular in the natural and the built environment, allocating a large importance to the so called "critical infrastructures", in social and economic systems.

A set of four matrices has been developed to identify what aspects, relevant parameters and factors should be looked at:

1. Before the impact: what shows the potential ability or inability to cope with an extreme?
2. At the impact: in particular, what shows the capacity (or incapacity) to sustain various types of stresses (in the form of acceleration, pressure, heat…)?
3. In the time immediately after the impact: what shows the ability (or inability) to suffer losses and still continue functioning?
4. In the longer term of recovery: what shows the capacity to find a new state of equilibrium in which the fragilities manifested during and after the impact?

A particular attention was paid to the relationships among systems within the same matrix and among matrices, across spatial and temporal scales. A set of matrices has been developed for different natural hazards (landslides, floods, earthquakes, forest fires, volcanoes, droughts), trying to include as much as possible what past cases, the international literature and prior experience of involved partners have indicated as relevant parameters and factors to look at. In this regard, the project builds on the state of the art, embedding what has been learned until now in terms of response capacity to a variety of stresses and in the meantime identifying gaps to be addressed by future research.

The framework that was finally proposed embeds, in fact, some fundamental theoretical and practical aspects searched for in the previous work packages. It was in particular 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, it adopts a systemic approach at three distinct levels:

1. Vulnerability and resilience of systems is appraised (natural, built environment and social).
2. The term “systemic” has been associated to vulnerabilities that arise as a consequence of systems interdependency and interconnectedness.
3. The question of how vulnerability and resilience of different systems interact with one another across temporal and spatial scale has been addressed.

***Framework description (WP4, see Del4.1)***

The ENSURE framework responds to the requirement of general theoretical advancement that was one of the two main objectives of the project. Combining the different pieces of the puzzle (or what can be recognized as such) into a methodological framework comprising the various aspects that were deemed important by the working group is by no mean a minor result, even though we are aware of the long way ahead before all parts of it will be actually operationalized in a satisfactory way.

As it can be clearly seen in figure 2, the framework is deployed over a plan where both the spatial and the temporal dimensions are evidenced. As for the spatial one, the scales at which both hazards and vulnerabilities should be appraised are represented in two distinct axes. The reason is that not necessarily the scale at which hazards have to be analyzed corresponds to the scale at which the different types of vulnerabilities must be considered. For example, physical vulnerabilities are mainly addressed at the local scale, as the intrinsic fragility of structures, infrastructures, and people must be looked at in detail at the local scale. What appears at larger scale is the result of such analysis, in terms of comparison among places. As already mentioned, systemic vulnerability can be appropriately considered only linking the local to the large scale (provincial or county level to the regional and sometimes above regional). When it comes to consider the capabilities to recover effectively in a resilient fashion, all scales must be considered: what will be reconstructed is ultimately what has been locally damaged, but the needed resources cut across all levels of government and depend also on the type and strength of relationships among the affected places and a much wider region.

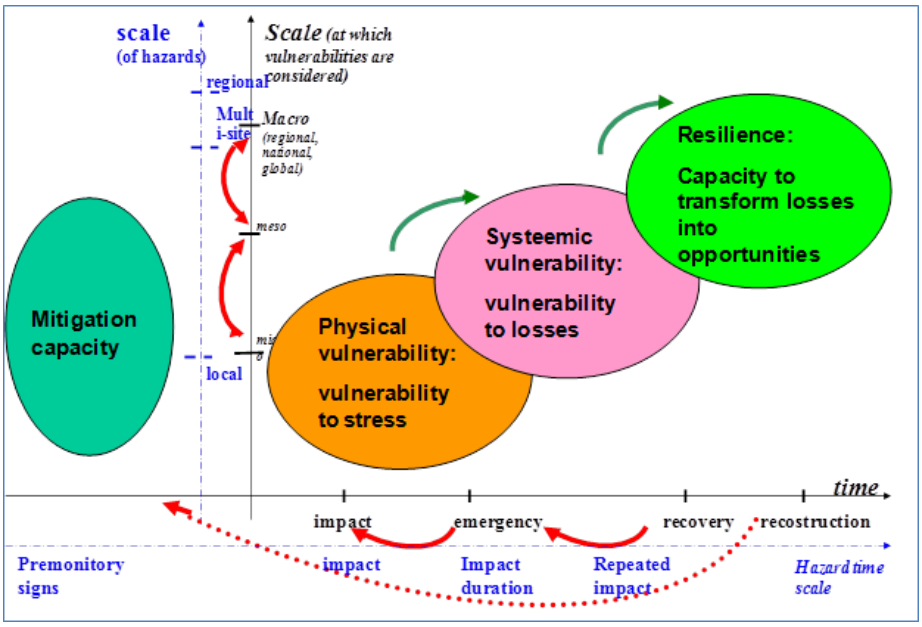


*Figure 2: ENSURE integrated framework to assess vulnerability and resilience across time and scales*

As for the temporal dimension, it is shown how the various vulnerabilities and resilience are considered with respect to the phases of the disaster cycle. Before the impact, that is when a sufficiently long time has passed since the last big event, the mitigation capacities are considered. Rose (2004) suggests that it is more correct to talk about mitigation capacities in the period before the hazard impact, while resilience should define more appropriately capacity to recover from an extreme event. This is nevertheless a matter of deciding the most suitable definition; what is actually relevant here is the attempt to understand whether or not conditions to enhance coping capacity and resistance of a complex system exist or not and how they are manifested. At the impact, instead, the physical vulnerabilities play the major role: the direct physical damage that can be accounted for are strongly correlated on the one hand to the severity of the hazard, on the other to the level of physical fragility of artifacts and constructions. As the time from the impact passes, other forms of vulnerability gain relevance and in particular during the emergency phase, precisely systemic vulnerabilities. Those express the response capacity (or lack of) not to the direct extreme event impact but rather the consequences of the latter, to the impairment in crucial systems and their components provoked by the physical damage. Finally, considering the time of reconstruction and recovery, resilience gain prominence: here again the response is not to the stress, but to the longer term induced, indirect, secondary effects it has produced. What we want to measure here is not merely a response capacity, but rather whether or not systems are able to recover by reducing pre-event vulnerabilities, to learn from the weaknesses that the event has revealed and to transform reconstruction into an opportunity to build and develop a better, safer and healthier place to live.
The red and green arrows in Fig.2 represent the various connections and links that exist among the different types of vulnerability and resilience, in space and time.

### *Matrices description*

Each set of matrices, corresponding actually to one ellipsoid in figure 2, is in fact compounded by four sections or sub-matrices (see Table 1): the first set relates to the vulnerability of the natural environment; the second to the vulnerability of objects, artifacts, facilities; the third refers to critical infrastructures, such as lifelines and accessibility networks; the last refers to the vulnerability of agents.

In each matrix, vulnerability indicators taken from literature and from past/on-going research carried out by the ENSURE team, are proposed.

In the first set of matrices, the capacity to mitigate is addressed; this means concretely that the vulnerability of the natural environment, the characteristics of the hazard are known, mapped and monitored appropriately. With respect to the vulnerability of objects and artifacts what is checked here is whether or not vulnerability assessment have been carried out and taken into consideration in planning and risk prevention policies; in the case of critical facilities, not only the awareness of systemic vulnerability is addressed but also the capacity to reduce it in ordinary maintenance programs and anytime new facilities or replacement of existing ones must be conducted. With respect to agents, their awareness of existing threats and fragilities is assessed as well as their willingness/capacity to address them when the hazard does not seem to impede in any particular fashion and time has passed since the last catastrophic event.

In the second set of matrices, the physical propensity to damage of the natural environment, objects, critical facilities and people is assessed. All factors that may increase the potential damage are considered, including the possibility of enchained effects, both between natural hazards (like for example landslides triggered by earthquakes) or between natural and vulnerable built systems (like for example na-tech).

In the third set of matrices, the potential reaction to first level losses is addressed: secondary effects in the natural environment, like for instance lahars or debris flows consequent to fires denudating entire slopes is considered. With respect to artifacts, urban areas and critical facilities, the capacity to keep functioning despite some level of physical damage is evaluated, considering the interdependencies among systems and among components of vital systems. With respect to agents, the capacity to manage emergencies, to endure in time of limited facilities and restricted access to resources and markets is considered.

Finally, in the last set of matrices, the recovery potential is appraised. As for the natural environment the ecological resilience is referred to, particularly for those hazards like fire or drought that may significantly disrupt the natural environment itself with permanent damage. For buildings and cities, the capacity to embed the lessons learnt in the disaster while reconstructing artifacts and places is evaluated, as well as the capacity to couple the physical reconstruction with the symbolic one, accompanying the healing process of a traumatized social system.

Regarding the latter, access to resources for reconstruction, availability of good administrative procedures, fast delivery of compensation are elements that seemed particularly relevant to accomplish a resilient recovery. Fast access to compensation need not to be taken as an isolated indicator: the capacity to couple it to the control of how reconstruction will proceed and to what extent pre event vulnerabilities will be addressed is equally if not more important.
In this respect, but as a general consideration for all set of matrices, indicators should not be considered as standing alone. Some must be appraised in conjunction with others in order to draw a vulnerability and resilience assessment of a given area and environment.

Each matrix is in its turn divided into four parts (see Table 1).

a) The first part relates to the natural environment. Indicators that can be found in this part respond to three main questions:

- Is the available knowledge, including its representation in maps, tables, and other forms, sufficient and sufficiently taken into account for decisions at each stage of the disaster event?
- Are enchained natural hazards considered in the hazard assessment?
  It should be noted that this and the previous question are not aimed at introducing surreptitiously hazard aspects into vulnerability analysis. Instead the point that is made here is that a given system is less vulnerable if hazards are well known, monitored and early warning systems are put in place when relevant.
- Finally which elements in ecosystems and in environmental settings are particularly vulnerable to the consequence of an extreme event (this is particularly true for forest fires and droughts) or to the mitigation measures which are taken to protect some other systems (for example lava

diverting systems to protect buildings and infrastructures that may lead to the destructions of forests)?

b) The second part relates to the built environment, considering the following aspects:

- Have buildings been built (or not) according to specific norms or to state of the art considering previous lessons learnt from past disasters? On the other hand, the position of buildings within hazardous zones has to be assessed. Clearly this is more the case of an “exposure” rather than a vulnerability factor.
- For public facilities, the question is whether there are further vulnerability factors that must be accounted for, regarding internal machinery, assets, tools that are fundamental for the functioning of a given service.
- As for the urban fabric, the point at stake is whether there are some vulnerability factors arising at the urban scale, going beyond the simple sum of the vulnerability of individual buildings and infrastructures, and which relate to the shape of the urban patterns, to the relationship between open and built spaces and with accessibility.

c) The third part regards critical facilities and production sites that are considered separately because of their importance in guaranteeing the survival of an urban system and for the well-being of the potentially affected community. From a theoretical point of view they may be seen in conjunction with the vulnerability of the built environment, but from a practical and strategic perspective it makes sense to separate them. Critical facilities gain their prominence when systemic vulnerability must be appraised.

d) The last part is devoted to the assessment of social systems and economic stakeholders’ vulnerability. Social systems’ and agents’ vulnerability has been considered with respect to three main sub-groups:

- Individuals vulnerability, related to the level of awareness and preparedness to both mitigate and face the consequences of an external stress;
- Institutions’ vulnerability, in which all agencies and organizations that may have a key role in both disaster management and disaster avoidance are considered.
- Finally economic stakeholders, who, similarly to institutions, may have a leading role in shaping vulnerability, in creating coping capacity mechanisms.

With the rather broad term of social vulnerability we address several components of societal coping capacity, ranging from individuals, to social groups, to communities, to organizations. Social vulnerability can be both physical and systemic, as people can be physically injured and harmed, but are also vulnerable to the lack of basic services, to the new conditions required by evacuation, temporary sheltering, et. In the same vein, organizations, like for example civil protection, can be harmed in their assets and personnel, or diminished in their capacity to react because of a variety of systemic failures, including the lack of coordination and collaboration among different agencies, problems in communication, problems in deciding about matters that hold significant juridical and moral challenges. An important distinction that has been introduced in WP2 is between social and human capital, intending that vulnerability of both should be appraised. For neither concepts, universally accepted definitions can be found. Basically, we can assume that human capital refers to skills, dexterity (physical, intellectual, psychological) and judgment capacity, which may be lost during an extreme event; on the other side, social capital refers to the value of social networks affecting the productivity and capability of individuals and groups to cope and recover from an extreme event.

With economic vulnerability we refer to the response economic sectors are able (or unable) to provide in the aftermath of an extreme event. Also in the case of economic vulnerability, both physical and systemic aspects must be considered. Economic assets can be physically damaged, but economic activities are clearly extremely vulnerable to interruption of transportation services, to

deficient lifelines. Days without the possibility to work, to receive products or to send them to destination constitute a net damage measurable in monetary terms.

As can be seen in Table 1, each matrix is organised into columns:

- The 1st column identifies the system to be assessed.
- The 2nd column identifies the components of the systems.
- The 3rd column clarifies the aspects that have to be considered in the choice of the indicator/parameter that may better respond to the question, shown in the third column.
- The 4th and 5th columns determine how indicators/parameters can be measured and assessed, upon what criteria and using what tools (maps, diagrams and scores).
- In the last column, references are made either to a case study that was analyzed in detail or to several cases that are relevant to the specific indicator at stake.

It has been decided to produce a set of matrices for each “hazard”. Methodologically it seemed useful to check to what extent the individual parameters in each set of matrices had to be differentiated upon the expected threat. In fact not only the physical response to the stress is so to say “hazard” dependent. In each hazard different aspects related to monitoring and mapping must be considered, different specific mitigation measures must be taken before and after the impact.
Therefore, as a first step, different matrices have been developed for each hazard.

*Table 1. General structure of matrices*

| System | Component | Aspect | Aspect parameter | Criteria for assessment | Comments/ case study |
|---|---|---|---|---|---|
| **Natural environment** | Natural Hazards | Existence and quality of mapping and monitoring | Specific parameters to permit assessment of the aspects that have been identified as relevant | Criteria may range from binary (yes/no) to degree (corresponding to judgments) or to more physical measures (for example related to time needed for ecosystems to recover) | Specific parameters to permit assessment of the aspects that have been identified as relevant |
| | Enchained Events | assessment of hazards triggered by other hazards | | | |
| | Ecosystems | Fragility to hazards and to mitigation measures | | | |
| | | | | | |
| **Built environment** | Residential Buildings | Existence and compliance with codes and land use planning regulations | Specific parameters translating into measurable factors the aspect to be assessed | Criteria for multiple measurement modality are provided; they also depend on the scale at which the assessment is carried out | Building codes exist for some hazards (particularly seismic) and not for others; nevertheless research in the field of resistance assessment to various types of stress has evolved in the last decades |
| | Public Facilities | Existence of vulnerability assessment and their consideration on mitigation strategies or in emergency plans | | | |
| | | | | | |
| **Infrastructure and production site** | Critical Facilities | Existence of strategies addressing the interdependency and the functioning of critical facilities under extreme conditions | Parameters to specify conditions at which crucial lifelines and utilities can keep functioning are provided, as well as to address the potential for Na-tech | Criteria for assessment are provided; proposed criteria reflect the need to address the interaction across spatial scales of such facilities | Critical facilities and production sites are clearly part of the built environment. Nevertheless a specific group of rows have been dedicated to them because of their relevance. |
| | Production Facilities | Existence of plans and procedures to maintain production in safe conditions given the possibility of an extreme event | | | |
| | | | | | |
| **Social system (agents)** | People/ Individuals | Weaknesses vs. preparedness of individuals | Most of those are qualitative parameters to assess the general level of preparedness and recovery capacity (or lack of) to traumas and discomfort provoked by potential disasters | Criteria for evaluating the parameters are provided, taking into consideration the different spatial scales at which individuals, institutions and economic agents act | Whilst the previous groups of systems relate more to the "physical environment", clearly this one embeds the results of decades of social sciences research in the field of risk and disasters studies |
| | Community and Institutions | Weaknesses vs. preparedness of organisations and institutions | | | |
| | Economic Stakeholders | Preparedness and recovery capacity (or lack of) economic stakeholders | | | |

***Framework applications (WP5, see Del5.3.1 to Del5.3.5)***

The main objective of WP5 was to apply the integrated conceptual approach for vulnerability and resilience assessment, developed in previous WPs and especially in WP4, to some selected case studies. In this way, we could specify and exemplify the inherent relationships between various types of vulnerability and to recognize and understand driving forces of the vulnerability for the representative environmental systems and hazards. The structure and spatial components of the territories, settlements, communities and the relations between these components, all in their dynamic, could be thus understood and serve as a basis for estimating system's coping capacity and the ways to mitigate hazards. Applications served also to highlight possible strengths and weaknesses of the proposed integrated framework.

It took time, to the research groups, to relate between the general view of the systems' vulnerability that was developed for the maximal possible spectrum of systems and hazards, and the specific case studies.

From the work in WP5, our understanding of the outputs of the case studies has evolved in an essential manner. The research conducted during the WP1 – WP4 have clearly shown the importance of the spatial information about the case studies, as well as the time factors. Regarding space, modern GIS provides effective tools for storage, management and analyzing of spatial information. Consequently, during the preparatory survey and data setting (Task 5.1), the teams responsible for the three main case studies, namely the Negev desert in Israel (droughts), Ilia Prefecture in Greece (forest fires, earthquakes and floods) and Vulcano Island in Italy (earthquakes, volcano), have invested essential efforts into developing GIS databases (all based on the ArcGIS and, thus, compatible). These databases contain essential high-resolution information on the major components of the investigated systems.

Various types of maps could be produced for analysis:

- In the Negev's case, these were maps of the settlements, agriculture and urban land-uses, precipitation, irrigation system.
- For the Vulcano case, these were seismic maps, Digital Elevation Model, layers of roads, land uses, buildings, vegetation and the expected expansion of lahars and volcanic bombs.
- In the Ilia case, these were maps of geology, socio-economic factors (economic indicators, settlements and roads, etc.), seismic hazards and ecological factors and risks (vegetation, forests, flammability).

Specification of the vulnerability matrices of the ENSURE framework and their application to the case studies demanded essential work (Task5.2). While interpretation of the general aspects of vulnerability that regarded the major systems' compartments went relatively easily, the interpretation of the general scheme in regards to the influence of the hazards on the relationships between the components demanded deeper understanding. The recognition of the relationships between the systems' components has essentially strengthened the importance of the connection between the theoretical and applied work on vulnerability. Eventually interesting and relevant results were delivered as outlined below.

The investigation of the case studies and the implementation of the theoretical results in each of them were established during the meetings that were held at the three main case study locations.

The first “case study” meeting took place at Vulcano Island (Italy) in May 2009 and it constituted a proper background for relating between the concepts developed within ENSURE and the real-world territorial systems. At this meeting, a common view of the vulnerability concepts was specified for the Vulcano case study. The volcano eruption may take relatively short time or last longer; it cannot be influenced during the event; it can be essentially destructive but the spatial extension of the damage is limited. The preparedness of the system to the hazard is of the foremost value in this case. The walks and excursions over the island raised critical, for this application, issues of physical vulnerability of the constructions and social vulnerability of the small island society and summer tourist population.

The second meeting in the Negev (Israel), in February 2010, was focused on the vulnerability of the Negev's territorial system to long-term drought hazard. In this case, the development of the hazard is well-known and expected; it continues for years and the problem is in understanding its consequences as they develop in time. This understanding is necessary for suggesting mitigation measures that would reduce or prevent the system degradation and the time-schedule of measures' implementation. At this meeting the common view of the system vulnerability was specified and agreed upon. The participants performed a series of exercises aimed at constructing vulnerability matrices for different cases and accepted common interpretation of the basic notions.

The third and last "case study" meeting in Ilia (Greece) in October 2010 was focused on the large-scale vulnerability of the region to the short-acting catastrophic hazard, as earthquake and forest fire. During the field trips ENSURE participants observed great variety of Ilia landscapes, the various types of damages caused by the 2007 mega-fires there, and the natural and human-driven ways of restoration of the ecological and socio-economic systems after the disaster. The great variety of the landscapes and biotopes in the Ilia area clearly demonstrated the importance of the spatial aspect of vulnerability. Both the Negev and Ilia case studies consider extended territorial systems of 5,000 to 10,000 sq.km size. However, the heterogeneity of the Ilia territorial system is several times higher than that of the Negev and, thus, Ilia study is the case where the methodological issues that are related to ENSURE framework could be fully implemented. During the Ilia meeting, the partners finalized their conceptual view of the spatio-temporal vulnerability of the territorial systems.

The meetings and field trips guaranteed successful interpretation of the theoretical framework, developed during the WP4, in these three main case studies.

The significant results from the application of the methodological framework to the selected case studies are the following: (1) a systemic approach to understand vulnerabilities and relationships in each specific context is the key for a proper vulnerability assessment; (2) the proposed matrices are able to depict the ways in which the territorial system reacts to the natural threat; they present different aspects of mitigation capacities and foresee potential losses and long-term dangers at all levels of the system hierarchy and for all major components of the system; (3) the framework is able to point out areas where the development of mitigation measures to cope with a given hazard may not be sufficient; (4) space and time factors, as well as scale consideration, are indispensable in the understanding of the various types of vulnerabilities and their linkages.

### *Working with vulnerability and resilience parameters*

As already mentioned, few studies have attempted insofar to clarify how different types of vulnerabilities should be accommodated in one integrated study and what process should lead to the identification of suitable indicators. Studies in this regard can be found regarding sustainability indicators and reports for countries or urban areas (see in particular MacLaren1996; Winograd and Farrow, n.d.). Those studies discuss the criteria that should drive any effort to develop sustainability indicators. The latter are rather useful for the present project, as the concept of sustainability is as difficult to measure as is vulnerability. Both require to capture the complex interrelationship among different systems which interact at various spatio-temporal scales, in a parallel and even in a cross cutting fashion.

One important difference seems to distinguish vulnerability from sustainability: while in the latter the verification process is extremely difficult, as it requires confronting the state and the process toward sustainability with impacts that cannot be fully envisaged, in the case of vulnerability indicators, the latter can be confronted once an extreme event occurs with actual damages. This is perhaps more true for physical, some kind of systemic, social and economic vulnerabilities than for others, in particular resilience parameters. At least in principle, though, it is possible to compare the vulnerability assessed before the event and the damage occurring afterwards as well as to compare the expected response capacity with the way an actual event has been managed. In the meantime the establishment of good vulnerability indicators permits to enlighten aspects and types of losses that should be considered and checked in any event aftermath, so as to gain a reference value against which the validity of vulnerability indicators and of key measures can be evaluated.

This means that the distinction between different kinds of vulnerability should encourage estimating coherently damages, distinguished among physical damage to buildings and infrastructures, damage to economic assets and activities, losses to human and social capital, secondary consequences in terms of functional failure of fundamental services an activities.

On the other end, studies which are currently addressing the issue of how to find the best fit vulnerability indicators are being developed in the climate change community (see for example Eriksen and Kelly, 2007; Adger et al., 2004). Those studies are particularly enlightening in that they drive our attention to the need to capture complex processes and relations among indicators, and not just provide a state diagnostic, which may be limited in relevance as far as potential usefulness by end users and decision makers.

Therefore, before entering into the discussion of the validity of each individual parameter that has been selected, the criteria that have driven the same choice should be discussed. The latter can be synthetized according to the diagram shown in figure 3.

Criteria are grouped along three main axes:

- On the x axis, the inherent characteristics of indicators are addressed;
- On the y axis, the characteristics of the data to be used to assess the indicators value in a given place are shown;
- On the z axis, the usefulness of indicators is appraised.

a) With respect to the inherent indicators characteristics, the following have been granted importance in the literature:

- **Measurability.** The complexity of phenomena and societal response to natural calamities cannot be fully grasped just using indicators. In the meantime, we believe the latter should be intended as proxies of complex aspects and systems characteristics, so as to be able to achieve some important goals, such as: (1) comparability among places and communities, to establish priorities and identify key specificities as well as constant features; (2) possibility to assess, though with large uncertainties, to what extent given policies and strategies are able to move the system towards increasing or decreasing vulnerability levels.
  Measurability means here quantitative, as well as qualitative measures, which allow constructing some sort of qualitative grouping of values referring to a benchmark or values established by previous research and findings.
- **Specificity.** Indicators should address as much as possible specific vulnerability aspects rather than generic features that do not help in understanding what makes a given area or a given society more or less prone to suffer the consequences of an external stress. As mentioned in a previous deliverable, for example, economic disadvantage is not per se a measure of vulnerability: it becomes such when we are able to demonstrate how a poor response and low coping capacity is linked to limited access to financial resources and to services.
- **Representativeness**. Indicators should represent a wide set of cases and situations rather than being constructed after each individual case. This requires that indicators are chosen after they have been recognized as constant elements in several similar cases or across scales and regions or across different risks. Indicators cannot be too tailored to the specific case at stake, even though calibration procedures must be carried out; on the other hand, they must guarantee a minimal level of generalization, to be supported by statistical analysis. While this requirement can be met for physical vulnerability, it is far more complicated and thus constitutes more an aim than an established feature, for the less investigated aspects, like social, systemic, and economic.

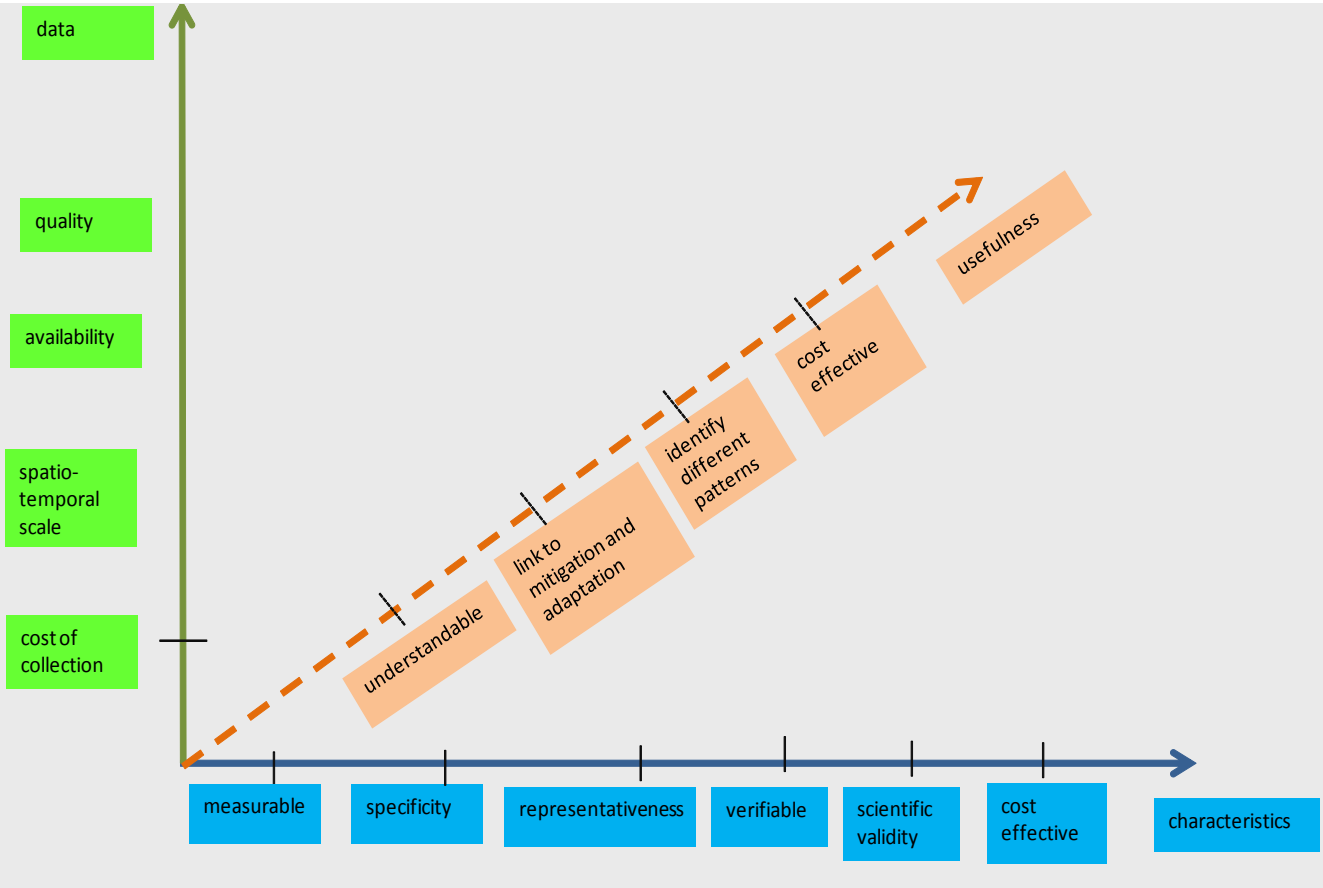


*Figure 3: Criteria to identify and select vulnerability indicators*

- **Verifiability**. There is the need to tune the search of correlations between indicators and surveyed damages after disasters, so as to be able to improve the capacity of indicators to elicit those systems characteristics that seem to be the root causes of poor or mediocre response.
- **Scientific validity** (regrouping all features mentioned above, particularly when we talk about measurability and verifiability). Indicators should meet the agreement of a large scientific community and should strive toward objectivity, even though we are all aware about the large room for subjective and even arbitrary judgment that is inevitably involved in any complex environmental assessment requiring to bridge among natural and human systems. Nevertheless, requirement about indicators is that they be chosen as rigorously as possible, be framed in a transparent conceptual framework linking the selected indicators to the notion that must be evaluated (in our case vulnerabilities).

b) With respect to data characteristics, the following criteria should be met, while looking for vulnerability indicators:

- **Data quality** is an important requirement, even though many times, only poor quality data are available, particularly for indicators that are not part of a long and well established tradition. In this case, perhaps it can be recommended that at least the quality of data will be made explicit so that assessors can judge to what extent the related indicator can be considered reliable. In fact, in designing a general framework, it is rather hard to dismiss all indictors for which data are not available in a given country or region good: this would be too limiting, also considering the fact that data quality differ enormously from one region to another and sometimes even from one municipality to another. Therefore eliminating indicators on this basis would diminish the relevance of assessments also in areas where data quality is high and the information that can be obtained may be very valuable for mitigation purposes.

- Indicators of vulnerability are required to cover different **spatio-temporal scales**, when this is relevant for the final assessment. In this regard, data should be available accordingly at the needed spatio-temporal scales. Similarly to what has been said for data quality, this requirement, while valid in principle, can prove to be too limitative in some situations and particularly currently, as many data are not available because they have never or poorly been considered until now for risk mitigation purposes. As said above, the framework and the proposed indicators should set a sort of pathway for future damage assessment, to capture the attention of analysts on aspects that have been neglected insofar.
- **Availability** should be considered also over time, particularly when processes must be captured: data that are available only at a given time spot do not permit to follow processes or to monitor whether or not a given system is becoming less or more vulnerable over time.

c) The entire method is being designed to guide and orient amidst mitigation strategies. In this respect, how useful proposed indicators are in enhancing the latter must be asked as well. Usefulness in this regard does constitute an important criterion for indicators selection.

- The first requirement is that indicators be **understandable** by users, not only as far as terminology is concerned, but also in the way they are measured, reference values selected and actually used in the assessment. This is a fundamental requirement should indicators be discussed with concerned stakeholders and be used by them as part of their ordinary planning a programming activities (of land use and spatial planning, granting permissions, deciding about infrastructures modernization, etc.).
- Indicators should provide directly or indirectly a door towards a set of strategies aimed at mitigating present levels of risk. In this regard they should not be only “descriptive” of a given situation, but also be **linked to potential intervention policies**, both as goals to be achieved and as factors against which achievements can be monitored and appraised.
- Perhaps the most important requirement with respect to all those defined insofar, relates to what extent proposed indicators permit to **distinguish different patterns** in a given areas, eliciting so called “pockets” or hotspots of vulnerability. In general, it is an important requirement that using the indicators, differences among conditions, individual areas, zones, parts of community, and communities are sorted out, so that priorities can be decided and tailored measures designed.

The “**cost effectiveness**” requirement has been left at the end to be considered collectively across all axes.

Talking about data collection, cost effective means that a reasonable cost is associated to the operations needed to gather the required data. In this respect it is commonly known that census data, data derived from national and international databases are often preferred, not only because they are cheaper, but also because they guarantee coverage over time and across scales, and can be used for comparative purposes. A balance must be obtained between the requirement of good quality data, optimized for the needed level of detail, and cost of collection.

Talking about **usefulness**, indicators that require too complex mechanisms to obtain data, or data that are privately hold or covered by secrecy are of limited use.

Finally cost effectiveness can be measures also from a cognitive viewpoint: indicators that are too complex to construct, that require sophisticated and opaque operations to be assessed should be carefully considered, given the large uncertainties they may entail. In the meantime, also the total number of indicators must be the object of reflection: endless lists of indicators are not only difficult to use, but also raise questions about the actual possibility to guarantee the other requirements of quality and usefulness that have been described until now. From a cognitive point of view, sustainability studies warn against the excessive number of parameters that nobody is able to neither handle nor master.

The application of the framework to the test case study areas provided a crucial return in terms of acquired experience and highlighted both strengths and weaknesses of the methodology.

The framework is at a stage of a prototype; some difficulties in applying it to concrete cases derive from this inherent character. On the other end, the experiences gained in applying the framework evidenced some points that could be hardly raised based on theoretical perspectives only. The most relevant aspect relates to the need to include the framework into a larger assessment procedure, where the fulfillment of the matrices is still the most relevant part, but not the exclusive one.

In other terms one must consider the evolution (both in time and as far as research efforts must be taken into account) of the framework and the related matrices. First a general scheme has been produced, in the attempt to capture the most relevant components, features, issues raised in the discussion about vulnerability and resilience and ways to measure and understand to what extent a given area, a given system is more or less vulnerable and/or resilient. Second, the general scheme was specified, choosing as a methodological path to tailor the parameters and criteria to appraise vulnerability and resilience with respect to distinct hazards.

Indicators received a specific connotation, showing what were the main features and aspects making a given environment (natural/built/social) more or less prone to damage and more or less capable to mitigate and/or recover. Such tailoring entailed a choice which is somehow questionable, as reference to individual hazards is explicitly made while the ambition to be general/comprehensive/multirisk is temporarily abandoned in favor of a more traditional kind of approach. The pro of such choice though, has been the potential of exploring vulnerability and resilience across several cases, defining in a much more precise and concrete manner what makes a given environment more or less fragile.

Still, even with this level of specification, matrices remain at a “general” level, somehow independent from specific contexts. And here the issue of how to adapt the assessment to the understanding of the context pops out in a very relevant fashion. Application to test case study areas evidenced that a clear cut straightforward application of the methodology, and in particular of the framework and the matrices, is not possible. One may even say that this could have been expected since the beginning and that actually an obvious process of tailoring and adaptation, this time to the context at stake had necessarily to be forecasted. In any case, testing showed in a very evident way this need. Therefore a clarification is needed on how to use the framework, even at an experimental stage, before moving from the prototype towards a more ready-to-use tool.

### *Critical discussion of the framework*

Qualitative versus quantitative parameters: a misplaced question

As stated at the beginning, and as explicitly stated since the beginning of the ENSURE project proposal, one of the main needs felt by the partners was and still is to integrated within vulnerability and resilience assessments both “hard” sciences indicators and factors, elements addressed by social scientists in disaster studies. “Hard” sciences provide information and insight to understand why given infrastructures and structures fail under given stress, be it the physical stress of the natural agent or the malfunctioning provoked by a certain level of physical damage to critical systems or components. Social sciences in their turn provide explanations and example showing how and why given communities are better equipped than others to face natural calamities. This has to do with the physical and functional consistency of assets, but also, in a meaningful portion to less “tangible” facts, entailing social cohesion, robustness of economy, cultural and human resources. The ENSURE project started its own research path from the recognition that mitigation policies must take into account the “two” sides of the coin (a coin is certainly a simplification, and a multifaceted prism should be better, yet it can be accepted for the purpose of the following discussion).

Conditions for better overcoming a crisis or a calamity depend on several circumstances and factors, which partially have to do with material components and partially with social, institutional and economic arrangements. Not to mention the fact that the “hard” and the “soft” sides are not

separated, they continually interact and such interaction produces fragilities and strengths. Therefore, any attempt to assess the response capacity to an extreme event, must consider both sides of the coin and possibly their mutual interconnection.

At the end, as stated by Winograd (N.d.), the goal of vulnerability assessments should be “turning the data into relevant information and information into action”.

Be it in the form of a list of factors to be considered or in more complicated schemes, as the one proposed in ENSURE, an agreement has to be reached (even a temporary one) between social and “hard” scientists/engineers.

The very first level is mutual respect and recognition of importance of matters which are studied by the other discipline. The second step is to face the objective difficulties and obstacles in making coexist two different mindsets and models of thinking and analysis.

In this respect, in the vast literature devoted to this certainly not new issue, a particularly insightful perspective is offered by Ginzburg in an article written in “History Workshop” in 1980. In the article, he discusses the main obstacles to mutual understanding and recognition, referring to the irreducible difficulties whenever the “human” component has to be considered, something which sounds certainly familiar to most “hard” scientists working in the field of risk. Whilst a couple of decades of interdisciplinary research have set the floor for a different attitude with respect to the past, and as more mature positions have emerged recently, overcoming complete lack of communication and disciplinary barriers, there are still key issues that require further reflection and settling of divergent position. This is deemed to be relevant not only to improve communication and knowledge exchange between “social” and “hard” scientists to limit the discussion to the “big” categories (whereas we are perfectly conscious that large gaps exist also within each “block”) but also to answer a key question for the project: are vulnerability and resilience assessment “science”. And as a next question, going after a similar one posed by scholars in sustainability “science” (Bell and Morse, 2008): are vulnerability and resilience assessment “good” or “bad” science or even “bad transposition of otherwise good science”?

Ginzburg suggests that there are two main irreducible differences between what he calls Galilean and social sciences: on the one hand the treatment of the individual as opposed to the typical and therefore treatable in statistical (quantitative) terms and the capacity to predict the behavior of a variable, the evolution of a given phenomenon.

As for the first point, clearly social sciences cannot avoid studying the individual, without losing critical information and understanding; attempts made by some social scientists to get closer to hard sciences resulted in rather “meager” results according to Ginzburg. In the meantime the author asks whether or not we can get to a situation where the understanding of the individual is somehow “scientific”, if conjectures that characterize “soft” sciences can be as rigorous as quantitative modeling. Without entering into the much wider debate of the so called “post normal science”, in which for example Funtowicz and Ravetz (1990) demonstrated that even “hard” sciences have undergone a significant mutation that has brought them quite far from the Galilean model, the point made by Ginzburg is still relevant. Ginzburg points at the divergent mindsets, according to which “hard” and social scientists judge method and rigor, still constituting a formidable obstacle to working together.

In the case of vulnerability and resilience studies, we may even go further and state that the point is not just making the two fields communicate, but actually develop possibly good science at the border of the two fields (and the many more disciplines within each) to address issues that are both and sometimes in the meantime material, physical and human, social. Continuing referring to Ginzburg’s article, resilience and vulnerability assessments resemble to a “medicine” type of effort, where classifications of diseases (in our case classes/categories of vulnerability) and the symptoms to be considered (the indicators) and how to judge their relevance and severity (criteria for assessment) are at stake. Within the framework, some indicators respond more to a Galilean type of science, when statistical methods and sufficient data can be used for their assessment (typically

most of physical vulnerability parameters and some systemic in the sense adopted by the project). Many others (typically all those referring to the social and economic systems) will remain at a "classificatory level". The point is therefore whether or not the two types of assessments can or even should coexist in the same framework. We think that even though in a rather imperfect way, the framework provides an acceptable level of integrated vision of the different aspects that must be taken into account in vulnerability and resilience assessments, without sacrificing relevant fields where knowledge on response of social, built and natural environments to extreme has been produced.

We are of course aware of some inevitable limitations such an endeavor implied since the beginning.

First, it is clear that the different indicators and parameters do not simply address different issues, but actually manifest also different ways of capturing vulnerability. Their co-existence in the framework is somehow arbitrary, as they actually play at different levels, not only in spatial and temporal scales, but also conceptually.

Nevertheless, given this minus, the framework offers a synoptic vision of what current literature and experiences have produced insofar, posing in a transparent way and in open access terms the question of how different views can/cannot coexist to provide a more articulated and nuanced picture of a system or a territory at risk.

Second, it is as well recognized that the tool that has been developed is currently a prototype and should be managed as such. It cannot be simply given to potentially interested stakeholders leaving them "alone" in the application of the framework and the individual matrices.

As the application to the test case study areas evidenced, a number of intermediate steps must be followed in order to use it at best and none of them can be at the moment "standardized". Some of those preliminary steps can be considered part of more general and thorough procedure, where the use of the framework is certainly a core component but not the exclusive one. On the other hand, tuning and adaptation to the specific context at stake have to be made because of the prototype character of the framework and the related matrices. Therefore, in a further evolution of the methodology, a sort of discussion and participatory approach should be taken, involving different stakeholders to understand with them for what specific purposes, how, to what extent, and with which changes the methodology can be successfully applied.

Apparently, considerations made by the various teams working on the test case study areas showed that the methodology, and the framework which constitutes its skeleton, are valid in that they set the floor for a comprehensive evaluation, considering multiple dimensions and facets of vulnerability and resilience. Difficulties arise in the assessment of some parameters, because of the way they have been conceived and constructed. Further research in this domain could enhance the applicability of parameters. On the other side, getting acquainted with the methodology requires some time and practice. Guidelines to help follow the methodology may certainly help, but as stated by Ginzburg «in medicine, history/human sciences (and we may add in vulnerability and resilience assessments), the elastic rigor – to use a contradictory phrase – of the conjectural paradigm seems impossible to eliminate. Nobody learns how to be a diagnostician simply applying rules».

This leads us to the second important difference between "hard" and "soft" sciences as discussed by Ginzburg: that is the prediction capacity (or lack of). Because of the relevance of the individual in social and human affairs, only a retrospective prediction can be attempted. The "conjectural" paradigm of history or criminology may reconstruct a posteriori an event or the scene of a crime. Much more difficult and even questionable is the possibility of "prospective" prediction, to forecast how the future will unfold, how and if a crime will be committed.

Whilst clearly even in "hard" sciences the capacity to predict is not that obvious and banal, particularly when large uncertainties are implied (see Sarewitz et al, 2000), still the evolution of variable with constant characteristics can be reasonably forecasted. As for disasters, the debate between those who held that each event is unique and those who privilege constant and repeated behaviors and patterns is still very harsh. Again the metaphor of medicine can be useful for

vulnerability and resilience assessments: indicators can be treated as “symptoms” of a condition the quality of which can be fully grasped only within a scenario type of exercise. Whilst the development of damage scenarios was beyond the application set for the ENSURE project, it became clear through the test case studies that only conditioning certain indicators to a predetermined scenario it was possible to fully appraise them, particularly when cross scale relationships were crucial.

Temporal and spatial scales: a viewpoint from the ENSURE project

The issue of scale has been rather neglected or poorly appreciated for a rather long extent, while in the meantime the concept of vulnerability, coping capacity, resilience and related concepts were undergoing a significant evolution process. It has become the center of interest and studies with the first applications of climate change scenarios, particularly when the latter had to be regionalized, and with the development of the first global integrated assessments of the state of the environment and risks. The main question that the latter analyses have raised regards the relevance for local places but even for regions of projections and scenarios that have been drawn considering global trends and processes, while neglecting the information that can be gathered locally. It was clear for the scientists in climate change and those involved in global environmental assessments that for some phenomena, what happens in a given place, or at a micro level cannot be always neglected, as sometime it may contribute to change the evolution or patterns at much larger scales. Therefore a reflection on the meaning and use of scale in such studies and conversely in natural hazards has broken through various research groups, producing insightful thoughts that are relevant also for the ENSURE project.

First, it should be said that introducing scale into vulnerability and resilience assessments is not easy, nor there are available standards or references that can be taken as guidance. But even in more general, theoretical terms «improving the understanding of linkages between macroscale and microscale is one of the great overarching intellectual challenges of our age in a wide range of sciences» (Willbanks and Kates, 1999). The authors continue suggesting that “weaknesses in appreciating the interaction of processes moving at different time scales and extents, in fact, underly a great deal of the current scientific interest in complexity, nonlinear dynamics, and the search for order amid seeming chaos”. The issue of scale is particularly important when different scientific perspectives must cooperate together in a truly interdisciplinary way. As suggested by Root and Schneider (1995) «the scale at which different research disciplines operate make multidisciplinary connection difficult and necessitate devising methods for bridging scale gaps». Having said that, it is clear that what can be realistically achieved within the ENSURE project is first an explicit recognition of the importance to consider the scale issue as a central one and second a proposal of how it can be operationalized within the proposed methodology.

In accordance with the already quoted definition of vulnerability provided by Turner et al (2003), we may well take the definition of scale as suggested by Gibson et al (2000): “We use the term scale to refer to the spatial, temporal, quantitative or analytical dimensions used by scientists to measure and study the objects and processes. Levels on the other hand refer to locations along a scale”.

In the suggested framework, both the spatial and the temporal scales of disasters are considered to structure the analysis of vulnerability and resilience. It is also suggested that even though both concepts are dynamic and dynamism is a crucial aspect to understand how and why given levels of vulnerability or resilience can be “measured” today, what can be practically achieved is a “picture” of frames at meaningful levels of the scale.

In order to operationalize the concept of scale, then two main aspects will be discussed in the following paragraphs: first what are the relevant levels for each scale to investigate for what purpose; second how we may treat cross-level and cross-scale relationships.

Insofar the framework description has provided a static picture of the vulnerability assessment, providing the explanation of what can be viewed as a skeleton comprised by subcomponents and indicators to enlighten and evidence the various factors that have been recognized in literature and past applications as relevant for understanding the potential response of a complex territorial system to the “external” stress due to a natural extreme.

The ENSURE team though has acknowledged since the first WPs (in particular WP2) that links, connections, coupling relations exist among indicators. More than that: the validity of a vulnerability assessment requires the understanding of such connections to avoid misleading results that do not take into account how the various factors interact in a real setting.

Given that, the issue of how to play on the relationships that have been sometimes grasped in back analysis within the framework has still to be fully understood.

At least three types of relations can be recognized (see figure 4).

The first one relates to how the different indicators within the same matrix may be connected to each other. In general term, it can be assumed that social agents in various forms may have a direct or indirect, strong or loose influence on all other types of vulnerability, that is on the vulnerability of natural systems (for example the decision to change the type of vegetation coverage for economic profitability may induce instability in slopes or give room for more inflammable species), on the vulnerability of the built environment (here the all issue of compliance with norms and state of the art techniques enters), on the vulnerability of critical infrastructures (not only the way they are constructed, but also to what extent they are privatized, whether or not managing companies are controlled, coordinated by public bodies, etc.).

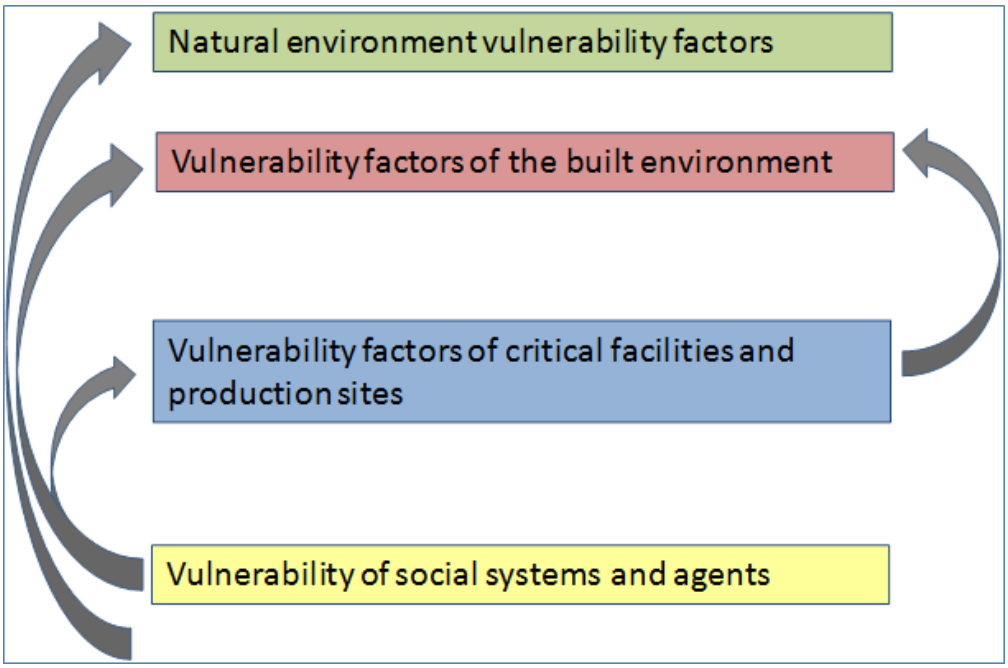


*Figure 4: Relations among indicators within the same matrix*

The second and third ones relate to spatial and temporal cross-scale and cross level connections.

The reason why we need to address the scale issue can be derived from the rather enlightening and systematic discussion by Willbanks and Kates (1999):

- For the “tractability” of the problem at stake: when considering for example the vulnerability of buildings, a one by one survey can be carried out in very small municipalities and in any case only locally; when the vulnerability of entire provinces, counties or regions must be appraised, sampling techniques or even statistical analysis based on poor data (like census data) has necessarily to be adopted. This does not mean that studies at larger scales are less reliable: they obviously serve another purpose that is the setting of strategies and policies identifying priorities, rather than deciding about individual interventions. Many other examples can be presented; in general it is true that vulnerability assessments regarding several components of vulnerability are much more tractable at the local scale, and the quality of information that can

be gathered is much higher. Nevertheless, the limitations of investigations conducted only at the local level should be pointed out as well. First, the resources necessary to carry out a thorough survey are limited and therefore many localities will not be covered because of lack of time, money, personnel; second, at the local scale some relevant factors influencing trends and conditions can be missed, as they operate at other scales or levels. It is rather hard, perhaps impossible, to identify the "right" scale or level at which to analyze a given problem, as the latter depend on the purpose of the assessment, on the available resources but also, importantly, on the type of patterns and phenomena that have to be investigated. This leads us to the next point.

- A multi-scale, multi-level approach is relevant whenever "emergent" aspects, patterns, relations emerge at higher (or lower) scales and levels and therefore missing them may invalidate the entire assessment. An example is provided by lifelines vulnerability assessment: because of their intrinsic hierarchical structure and of their mutual interdependence, studies conducted at a local level may completely miss the relevant interconnections that are both spatial and systemic. Furthermore not just one level is implicated in infrastructures organization: actually it depends on the specific arrangements in a given country or even continent. Before moving to the analysis of the local vulnerability of lifelines, one must estimate where the vital links, nodes, segments are. In this respect, it may be suggested that physical vulnerability assessment is more likely to be "local", whilst "systemic" vulnerability as defined in the ENSURE project is more likely to be grasped at higher levels, regional or national. Following Root and Schneider (1995) a "cyclical scaling" method has to be preferred to rigidly pre-defined "top-down" or "bottom-up" approaches, going from the local to the regional or national and back to the local, depending on the question to be answered with the vulnerability and resilience assessment.
- Considering multiple scales and levels supports even more strongly the need for a methodological strong framework as the one suggested by the ENSURE project. In fact, a definite rule valid for all types of assessments cannot be established, as the choice depends on the objective of the assessment but also on the systems to be analyzed and on the specific context where the analysis is carried out. Such a framework, by establishing how given parameters and topics must be addressed at what level and scale, is better fit than case by case analyses to accomplish what Willbanks and Kates (1999) see as key requirements: it puts localized observations into a reference context and increases the comparability of studies conducted at the same spatial level and across time. This is a requirement that has been stated, even though phrased in other ways, by the Asean group producing the Post Nargis Cyclone assessment of needs and damage in the affected Myanmar areas (2010). The latter shares with ENSURE a similar philosophy, according to which vulnerability and resilience evaluations are useful exercises only at the condition that they support and offer insight for deciding mitigation and prevention strategies.

Following what has been discussed until now, the following can be proposed for the ENSURE project in practical terms:

a. Scale up and down, adopting statistical and sampling techniques for those aspects (particularly physical vulnerability) that are cumulative (which means that the physical vulnerability of buildings in a region can be seen as the additional vulnerability of every single building);

b. For systemic vulnerability, a cycling scaling approach may be adopted, going up to the largest spatial scale necessary to identify functionality at the lower (or local) level of concern;

c. For mitigation and resilience, the appropriate spatial scale depends very significantly on the purpose and the end user of the assessment. In this case, a "mapping" approach following the one proposed by Briguglio et al. (2008, see figure 5) can be followed. In other words, one has to first identify in the case at stake what are the agents and the economic stakeholders that are most relevant for understanding a given pattern of preparedness (or lack of) and of capacity (or lack of) to influence physical and systemic vulnerability and then directs the efforts into the assessment of the elements at different spatial levels that are relevant for the case at stake. For example, while talking about the physical seismic vulnerability of buildings in a given region in

Italy, it may be relevant to search at the national level when laws providing economic incentives for retrofitting have been passed and what are the authorities in charge of controlling the correct use of those incentives. Then the appropriate level at which to analyze agents' behavior in this specific case can be decided.

Dealing with cross-level and cross-scale relationships

As it is already very complex as shown in the previous paragraph to address scale issues per se, it is even more challenging to tackle such cross-scale relationships. As already said, whilst the relevance of such connections has been recognized theoretically, it is still rather difficult to achieve it in real applications. Having a conceptual framework is already a good advancement as suggested by Roberts et al. (2009, see figure 6). Actually, their framework has a lot in common with ours, and can be suggested as a visualization of the kind of pre-vulnerability assessment that must be carried out in order to identify what are the relevant links among indicators at different spatial and temporal scale for a specific case at stake.

Again, it is deemed that a general theoretical statement of how those connections work is impossible at the state of the art (or perhaps even counterproductive form a conceptual viewpoint); instead, what can be practiced is the definition of a "scenario" where conditional relations among indicators are recognized as relevant and therefore for those indicators at the appropriate level of spatial scale the full assessment will be completed. The others will be as if "turned off" and not examined in that particular case.

Similarly for time scale (see figure 7), whilst it can be hold in general that what is decided in the period before the impact, the capacity or incapacity to mitigate have direct consequences on physical vulnerability, and on the systemic. The resilience of the system is not dependent only on pre-event decision, as emerging positive capacities may arise from society and territories in sometimes unexpected ways, difficult to fully envisage before the event. In this regard, while recovery and reconstruction clearly pave the floor for creating or eliminating vulnerabilities and are therefore always part of "mitigation" to the next, future, extreme event, the relation between mitigation and resilience is not necessarily so linear. Resilience, though, has to do with the expected level of damage, the extent to which places and communities are disrupted in the aftermath of the event.

In summary, it is clear that as it is already very challenging to account for cross-level and scale relations as well as for interactions among indicators in back analysis, in prospective assessments this becomes an unachievable goal, if prescribed in too strict terms. It is inevitable to simplify and propose a more pragmatic approach, that will first make explicit what kind of interactions among "stress → physical damage → systemic vulnerability → response to losses → assumed capacity to recover" can be envisaged in a given place, in a given region at the time when the assessment has to be conducted, and then identify the most relevant relations among what indicators at which spatial or temporal level.

Even though the proposed solution is partial and not fully satisfactory, it must be reminded though that it is in line with some current proposals that have been strongly supported by some end users. An example is provided by the already quoted Asean post Nargis assessment, where a very similar approach to the practical one we propose here was adopted, under extreme circumstances under the urgency to provide quick results for the affected communities. In fact, first a spatial grid was established to identify the key levels at which the assessment would be carried out; then an indicators' framework was set to guarantee both comparability and emergence of specific needs and problems in different localities; finally, the assessment looked ahead at recovery, providing a tool that could be used also across time to verify the efficacy of aid and intervention policies.

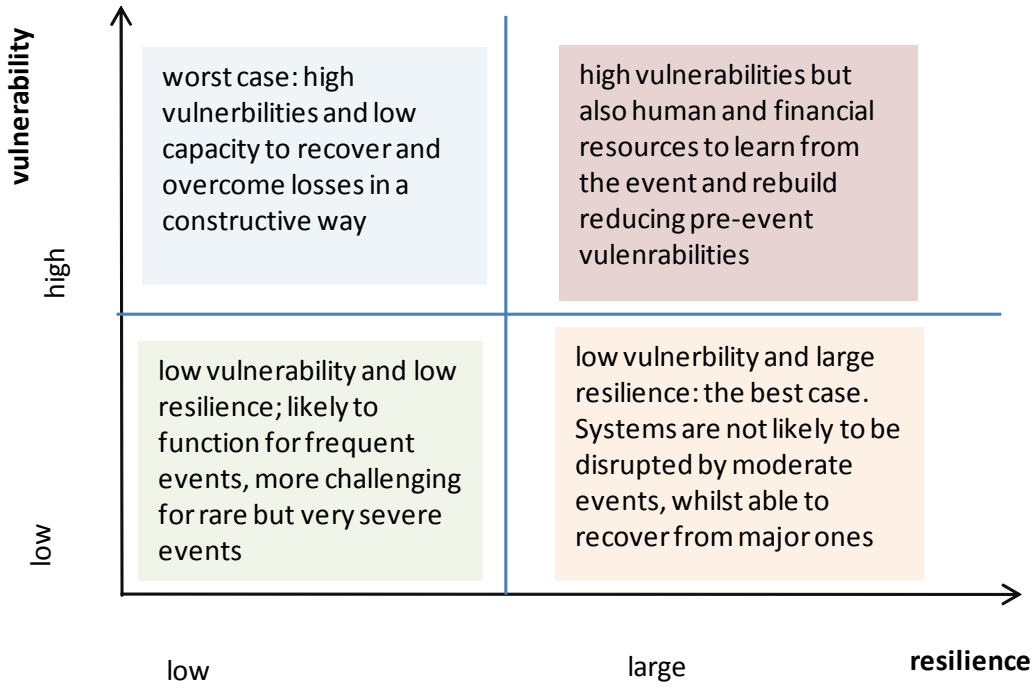


*Figure 5: Scheme to sketch the cross temporal scale relationship in a given area and context*

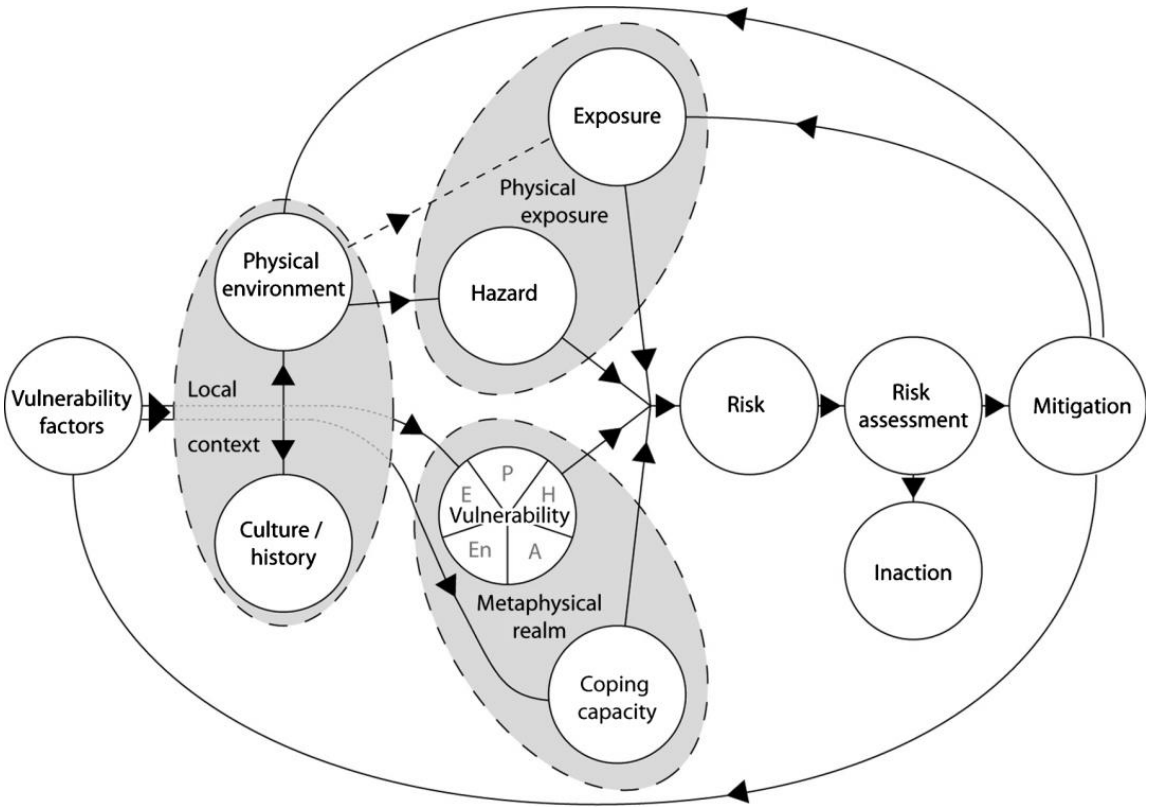


*Figure 6: Proposed model for vulnerability conceptualization within risk assessment context (after Roberts et al., 2009).*

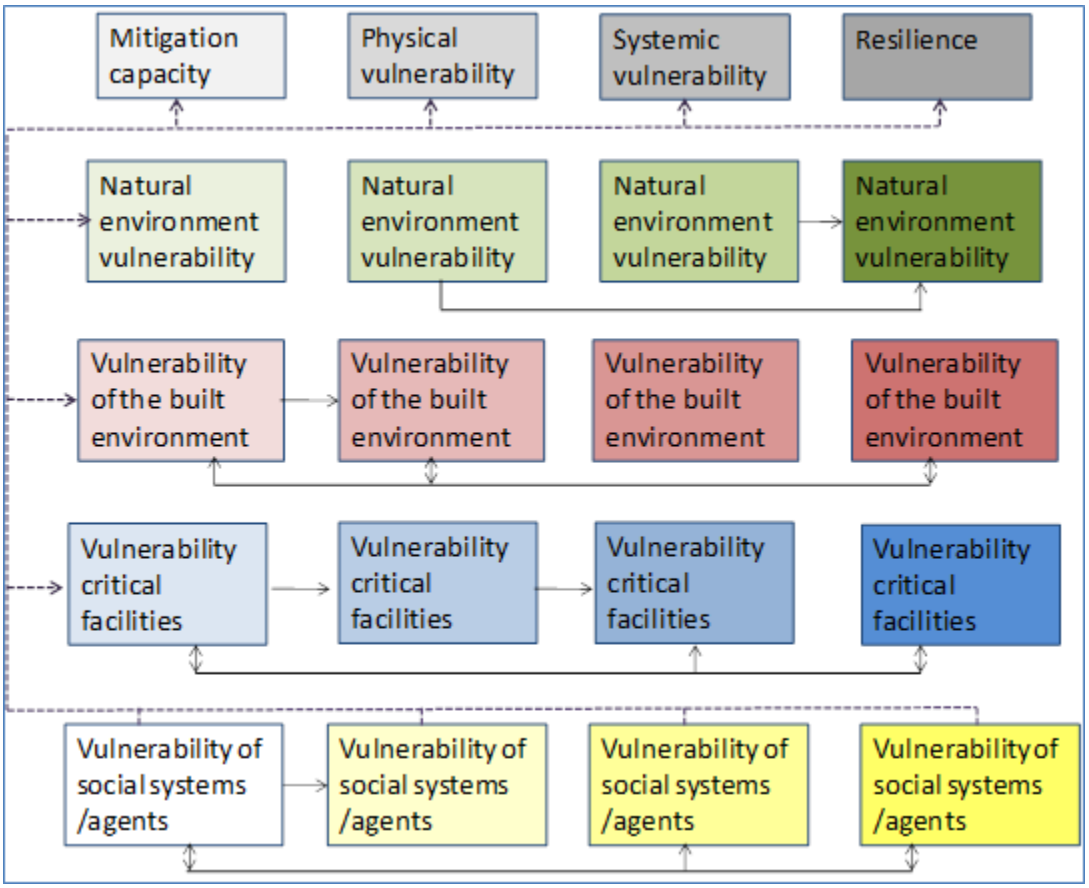


*Figure 7: Relations among indicators across the set of matrices (referred to time-scale levels)*

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## Potential impact

ENSURE implemented a comprehensive assessment on the impact of project activities and outcomes at political, social, economic and scientific level. Data reported and analysed in the following have been gathered trough a semi-structured questionnaire submitted three times to project partners. The impact analysis is divided in five parts:

Part 1: Identification of the main direct and indirect beneficiaries of the project

Part 2: Evaluation of the scientific impact

Part 3: Evaluation of the political impact

Part 4: Evaluation of the social impact

Part 5: Evaluation of the economic impact

### *Part 1: Identification of the main direct and indirect beneficiaries of the project*

The first category of direct users or beneficiaries of the project is represented by the civil protection and emergency actors. According to the partners, the main activities that they will be able to perform using the project's results, are emergency planning and "integration of research into new civil contingencies initiatives". The partners expect that, in developing their emergency plan, it will be possible for them to take into account the vulnerability concepts produced by ENSURE. Other expected impacts on this category are an increased resilience and an "increased awareness of the relevance of vulnerability and resilience assessment for an effective emergency planning".

Policy-makers and public authorities represent the second category of direct beneficiaries. The impacts on these beneficiaries vary with the countries and the level of responsibility, but they are all linked to territorial planning and vulnerability assessment. In Israel, the Ministry of Agriculture will be able, thanks to the project output, to suggest to farmers to improve cultivation practices and to develop the necessary water resources. This would result to increased crop yield. In Greece, the local authorities and the governmental agencies will get "new information and thematic maps on vulnerability" and "new knowledge on risk management". In Italy, thanks to the project, the local Authorities (especially those involved in the pilot case) will be able to "review their territorial land use plan by implementing a vulnerability analysis". According to the partners, ENSURE will "increase the awareness of the relevance of land use planning choices on vulnerability facets" and "improve planning in terms of mitigation of natural risks".

Students represent the third category of beneficiaries. Thanks to the project and to the e-learning tool developed, the students will benefit of a "greater efficiency in literature research and a major availability of conceptual framework for indicator development". Moreover, new enriched modules on vulnerability will be available for the students, with new issues for research and PhD theses.

The fourth category of direct beneficiaries is represented by the economic actors. To give an example: in Israel, the farmers will be able to improve their cultivation practices and to develop their water resources; consequently they could increase their crop yield.

The last category of direct beneficiaries is the research community. Thanks to the project there is a progress in the state-of-the-art in research on vulnerability in regard to natural hazards. ENSURE enables researchers to develop new planning instruments and can be useful also for the "conceptualization and use of vulnerability indicators".

The wider population of the territories is for sure most important categories of indirect users/beneficiaries. In fact, if the developed methodology of vulnerability assessment was to be implemented in a successful way, the population would be the first to benefit from a reduction of vulnerability and potential calamities in their territory.

The different types of impacts of ENSURE: scientific, social, political and economic consider the various categories of beneficiaries in different ways.

### *Part 2: Evaluation of the scientific impact*

As it can be expected for a research project such as ENSURE, the scientific impact is one of the major impacts of the project. In order to have a scientific impact, the methodology had to be innovative, of good quality and diffused effectively among the scientific community and support the development of further researches in the field. As we will see this objective has been successfully achieved.

In total, 14 articles have been presented to peer-review journals (and other 2 are in preparation), 3 articles have been published in non-peer-review journals, 6 books or books chapters have been written, 20 deliverables with scientific content have been elaborated and other 10 scientific material have been produced by the partners.

| | Year 1 | Year 2 | Year 3 | **Total** |
|---|---|---|---|---|
| Peer-reviewed articles (published, under review or in preparation) | 1 | 4 | 10 | **14** |
| Non peer-reviewed articles | 0 | 1 | 2 | **3** |
| Books (or chapters in books) | 1 | 0 | 5 | **6** |
| Deliverables | 5 | 6 | 9 | **20** |
| Other[1] | 1 | 1 | 12 | **10** |

*Table 1: Scientific production during ENSURE project*

Other scientific outputs are also of high importance. In total, 34 knowledge exchange initiatives with other research institutions have been carried out, 39 new collaboration links have been established, 27 scientific conferences and seminars have been organized and 12 new education materials have been produced.

Regarding the scientific impact of the project on education and training, we can foresee that this impact will increase even more after the end of the project. In fact, an e-learning tool has been realized at the end of the project, and the academic partners have expressed their intention to integrate the e-learning tool in the curricula of their respective fields (for example, POLIMI will integrated it in its course curriculum for Urban Planning). Moreover, the e-learning tool can also be used as an instrument for the public administrations to raise the stakeholders' awareness and improve their knowledge on the issues of vulnerability and resilience.

Besides these quantitative data collected through the questionnaire, we would like to present also a short qualitative analysis of the scientific impact on the basis of the exchanges between the partners.

One interesting achievement of ENSURE project regards the framework created in the project to facilitate the interdisciplinary work, a framework which provides the possibility for each expertise to locate itself within a larger and more comprehensive context. The partners have acquired a higher awareness of the difficulties of managing an interdisciplinary work and knowledge of some successful tools to organize the teamwork. This result is particularly important for the scientific community working on risks, hazards and prevention, because for these issues an interdisciplinary approach is essential.

### *Part 3: Evaluation of the political impact*

[1] "Other" covers different types of scientific productions such as thesis, papers for scientific conferences, etc. It contains also some presentations made for a scientific target, even if sometimes there can be an overlapping with the dissemination and communication activities.

As the main objective of the project was to develop an integrated vulnerability assessment methodology the political impact is mainly linked to the involvement of the main stakeholders in the application of and feedback on the methodology and its wide diffusion. Both aspects should lead to a major awareness of the stakeholders on the vulnerability assessment issue and to a major sense of ownership of the developed methodology that may be reflected in new policies, governance approach and related initiative-programs.

As mentioned before, three main pilot actions have been carried out in three different territories:

- on volcanic risks in Italy, Vulcano Islands;
- on fire, earthquake and flood hazards in Greece, Ilia Prefecture;
- on droughts in Israel.

The communities affected by the project are mainly the ones involved in these pilot actions. The main communities affected by the project are the ones threatened by the considered hazard/s in the pilot action: the Jewish and Bedouin populations of Israel that depend on agriculture and are very vulnerable to the droughts, the local communities of Ilia in Greece that have recently suffered important damages due to huge forest fires and the population of Vulcano Island, Italy, living on a volcano's slopes:

- In Israel, the project revealed strong interdependencies between the socio-economic vulnerability of the Bedouin and Jewish populations in the Negev during the periods of droughts. It highlighted the key issues that should be resolved to enhance the resilience of both populations.
- In Italy, the project provided insight on the compilation of a new emergency plan for Vulcano, and raised awareness among the school students on vulnerability issues.
- In Greece, the project has increased local social knowledge on vulnerability to forest fires, and local institutional knowledge and infrastructure regarding exposure, vulnerability and resilience versus this hazard.

Another indicator of the political impact is the extent of engagement of the social actors in the definition and the implementation of the project activities: 6 partners effectively engaged social actors beyond the research during the project. 2 partners engaged citizens or NGOs in determining what research should be performed; 1 partner engaged citizens or NGOs in the implementation of the research, and 2 partners engaged them in communicating, disseminating or using the results of the project.

An elevated number of stakeholders have shown interest or have been affected by the project activities.

The stakeholders involved in the pilot actions are linked to the territory in which the activities were carried out. They are mainly local and regional administrations and their services responsible for land protection and territorial planning, the civil protection services, citizens associations, professional associations, economic actors and citizens resident in the territories. In Israel, the Jewish National Fund was contacted because it is involved in providing grazing areas for the Bedouin herds, and the Israeli Association of Farmers because it is involved in supporting the Jewish agriculture settlements during droughts. The engagement of these stakeholders was crucial in the implementation of the pilot actions: it ensured that the implemented activities responded to the local needs, were shared with the involved population and organizations and will be sustainable in the future. In particular, in all the included countries the authorities responsible for land protection and risk assessment have been involved. This implies a high political impact at local level.

Besides the stakeholders involved in the project activities for the implementation of the pilot actions, other categories of stakeholders have been involved: National Authorities and Agencies, Academic actors, National associations and International Organizations that deal with vulnerability

assessment, civil contingencies and environment. Some stakeholders from Ethiopia have been involved, as a secondary theoretical pilot action has been carried out by ICT in this country.

The engagement of National Authorities and Agencies, National associations and International Organizations is a good way to increase the political impact of the project as it ensures a good dissemination of the developed methodology and it widens the possibilities of implementation of the methodology at a wider range in the coming years. In parallel, the fact that many stakeholders belong to the Academic world is another indicator of the high scientific impact of the project.

Regarding the engagement of public bodies, all partners were in contact with public bodies or policy-makers during the implementation of the project activities. 3 partners engaged with public bodies or policy-makers in framing the research agenda, 4 in implementing the research agenda and 7 in communicating, disseminating or using the results of the project. It may be considered normal (at least to a certain extent) that, in a research project, the policy-makers are mainly engaged in the last phase of the activities, the communication and dissemination phase.

Figures regarding the meetings with relevant policy-makers and stakeholders show that a very large number of meetings have been organized. In total 76 meetings took place over the three years, which represents in average of 7-8 meetings for each partner. This is an indicator of a high-quality policy impact and strengthens the probabilities of the use and application of the methodology in the coming years. Most meetings took place at local level, other were at regional, national and European level.

In total, throughout the whole duration of the project, 13 policy briefs have been produced and presented. Here again, it is to be expected that other policy recommendations will be elaborated in the months following the end of the project. Moreover, the final brochure of ENSURE contains general recommendations for policy-makers.

### *Part 4: Evaluation of the social impact*

Regarding the social impact of the ENSURE project the focus is on the territorial awareness. Dissemination and communication activities of the project were manifold, including workshops and dissemination events directed to administrations, schools or end-users. Some of the events were targeted to a small number of specific participants, whereas others were more generic with a high number of participants.

Moreover, one of the partners noted that: "the project has proofed to be extremely useful in the sense that communications skills concerning the concept of vulnerability between different scientific communities have definitely been sharpened in our institution. This opens a new window for cooperation since we feel now that better understanding can be achieved with other scientific domain regarding shared concepts."

Therefore, the varied and diversified communication and dissemination activities not only produced a high level of territorial awareness, but also had an impact on the competences and capacities of the partners.

### *Part 5: Evaluation of the economic impact*

As a research project, ENSURE has a very limited direct economic impact. The economic impact is more an indirect one: supporting the partner's organizations, the project has produced economic benefits for the community and the territory to which they belong. The fact that 76 persons have been working on the project, and that 13 job positions have been opened, produces an indirect impact on the families and the communities of the persons employed. 2 commercial collaborations have arisen from the project. Moreover, 27 partnership agreements have been stipulated, involving both partners internal to the consortium and external, and 39 new project proposals have been presented.

The entire impact assessment can be found as Del. 6.7-3.

## Main dissemination activities and exploitation of results

Dissemination activities of ENSURE were implemented in several ways and were planned and coordinated by the Dissemination and communication strategy which was set-up at the beginning of the project. It provides guidance to all project partners on the objectives in regard do project dissemination and the expectations towards them. Target audiences and activities were defined. Implemented dissemination activities were:

### *Project branding*

In the first months of the project, a logo has been developed for ENSURE and is used on all dissemination material, but also on the scientific outputs in order to create recognition. It was accompanied by a handbook for use of ENSURE logo and EC rules for publications.

*Figure 1: The ENSURE logo*

### *ENSURE project website*

The ENSURE project website has been established on http://www.ensureproject.eu. It gives an introduction to the vision of the ENSURE consortium, the partners, and documents for further reading. The website allows downloading all public deliverables and dissemination material of the project.


*Figure 2: The ENSURE project webpage*

An internal part of the website allowed the communication and exchange of documents within the consortium

### *Project brochures and CD Rom*

Two brochures were realized during the ENSURE project, one at the beginning at one at the end of the project.

The first brochure was intended to provide a brief project description (background, objectives, and expected impacts), present the project consortium (list of partners and their logos), give a reference for the EC financing, provide information on the project website and the way how to participate in project activities.

The final brochure presents the final scientific results of the project and provides a CD Rom with all public scientific deliverables, with a specific focus

***Scientific Colloquium on Integrated multi-scale vulnerability approach***

The ENSURE Final Workshop “Enhancing resilience of communities and territories facing natural and na-tech hazards” was held at BRGM, Orléans, France, on 10-11 May 2011. Approximately 100 representatives from the scientific community, civil protection and urban planning attended the event. The final event was at the same time a combined workshop with the MOVE project.

In fact, the workshop aimed at presenting results and outcomes of our FP7 project, dedicated to the development of a new methodological framework for Integrated Multi-Scale Vulnerability Assessment. The objective of this joint-dissemination was to raise new reflection on Vulnerability. A dialog between scientists and stakeholders took place during roundtables. Abstracts of all presentations were published.

***ENSURE e-learning tool on vulnerability and resilience assessment***
***http://ensure.metid.polimi.it***

At the end of the project an e-learning on-line course on vulnerability assessment was created in English. It shall provide students, young researches and professionals with the opportunity to learn on new approaches of vulnerability assessment with the main results from the ENSURE project.

The e-learning site is organized as a course without external assistance and has been conceived for the enhancement of the dissemination activities.

The learning path has been obtained from the ENSURE project contents and results and offers a sequence of themes, theories, methodologies, tools, and case studies the users can browse and experience. The website also offers activities to auto-test the achieved learning outcomes.

The choice for the contents and the design of the e-learning tool required a careful review of all the project documents produced and specific work to adapt them for use on a website. This adaptation was necessary because of the complexity itself of the subject matter – vulnerability and resilience to hazards – and because of the need to simplify such complexity into a clear and useful learning path.

The website has been developed to reach and involve a variety of students, practitioners and other technicians as target users. As each target group will have different learning and knowledge needs or goals, often the different categories of users are treated differently. However, in this case the e-learning tool has to be regarded as an additional method for disseminating the project’s results generally, therefore documents and activities offered on the e-learning platform are generally aimed at all users.

Finally, the e-learning tool aims at introducing users to the vulnerability and resilience assessment model proposed in the ENSURE project, specifying procedures, criteria and parameters to make it operable within a given territorial or cultural context. Case studies at local scales and within regional contexts complete the picture, proposing an approach for better understanding the articulated nature of the concepts of vulnerability and resilience (i.e. physical, economic, cultural, social and systemic) at different spatial scales (regional and local), useful for exploring the integration and connections of different types of vulnerability and resilience and for developing assessment processes and future scenarios.

The learning menu is composed of four main modules:

- two learning modules are devoted to theoretical and methodological issues related to Vulnerability and Resilience Concepts and Vulnerability and Resilience Assessment;
- the third module is devoted to the analysis of case studies;
- the fourth model contains final activities and exercises referring to the whole proposed learning contents.

In each module the user can find some brief introduction text, files containing the specific learning contents, exercises or examples useful to check the learning level obtained and links to the ENSURE final project documents, where it will be possible to find insights and details about the items discussed in the project. Each module is enriched by a selection of bibliographical references

and links to other websites to address users interested in deepening the theory and practice of vulnerability and resilience assessment.

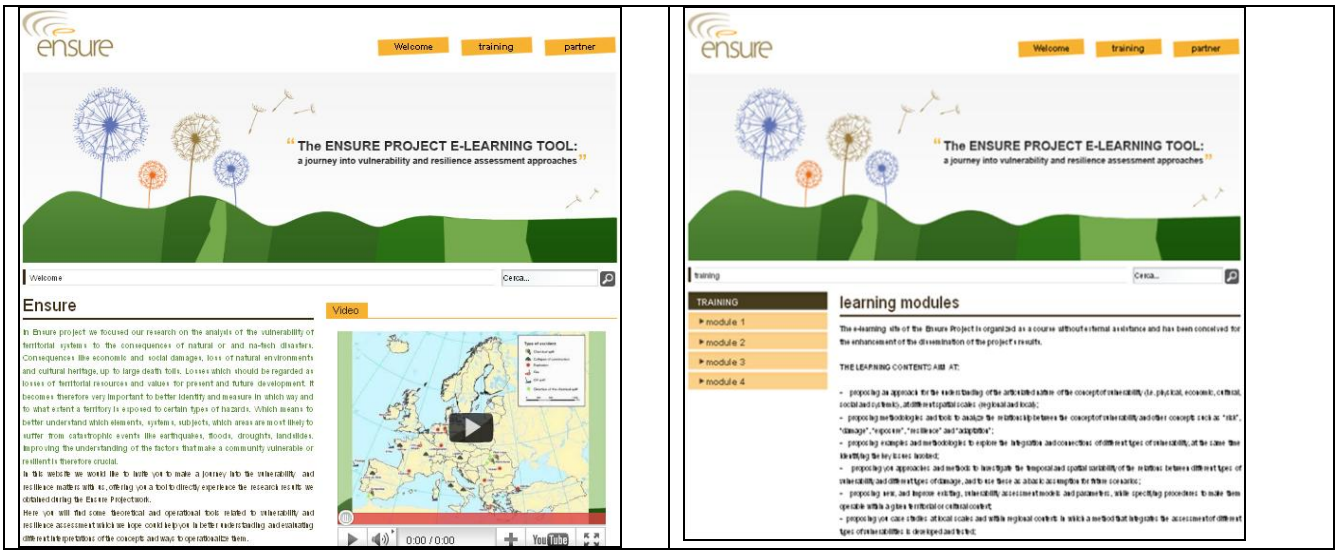


*Figure 3: The ENSURE e-learning tool*

Scientific publications, presentations of ENSURE in conferences and other dissemination activities are summarized in the tables of the next chapter.

No exploitation activities were planned, a part from the evaluation of impacts described before.

## Project website

http://www.ensureproject.eu

## 4.2 Use and dissemination of foreground

**Section A (public)**

This section includes two templates

- Table A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.
- Table A2: List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).

These tables are cumulative, which means that they should always show all publications and activities from the beginning until after the end of the project. Updates are possible at any time.

**TABLE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES**

| NO. | Title | Main author | Title of the periodical or the series | Number, date or frequency | Publisher | Place of publication | Year of publication | Relevant pages | Permanent identifiers[2] (if available) | Is/Will open access[3] provided to this publication? |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Towards sectoral and standardised vulnerability assessments: the example of heatwave impacts on human health | Lissner T, Holsten A, Walther C, KROPP JP | *Climatic Change* | [in press] | Springer | N/A | 2011 | N/A | N/A | No |
| 2 | Increasing pressure, declining water and eroding coast in NE | Tekken V, Ulazzi E, COSTA L, KROPP JP | *Journal of Coastal Conservation* | [in press] | Springer | N/A | 2011 | N/A | N/A | No |

[2] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

[3] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

| NO. | Title | Main author | Title of the periodical or the series | Number, date or frequency | Publisher | Place of publication | Year of publication | Relevant pages | Permanent identifiers[2] (if available) | Is/Will open access[3] provided to this publication? |
|---|---|---|---|---|---|---|---|---|---|---|
| | Morocco | | | | | | | | | |
| 3 | Sensitivity of Portuguese forest fires to climatic, human and landscape variables – Differences between fire drivers in extreme fire years and decadal averages | COSTA-CARVALHO L, Thonike K, Poulter B., Badeck F. | *Regional Environmental Change* | Online first | Springer | N/A | 2011 | N/A | doi: 10.1007/s10113-010-0169-6 | No |
| 4 | Quantifying long-range correlations in complex networks beyond nearest neighbors | Rybski D, Rozenfeld HD, KROPP JP | *Europhysics Letters* | 90: 28002 | European Physical Society | N/A | 2010 | 28002ff | doi: 10.1209/0295-5075/90/28002 | No |
| 5 | Extreme Events and Disasters: A Window of Opportunity? Analysis of changes, formal and informal responses after mega-disasters | Birkmann, Buckle, Jaeger, Pelling, Setiadi, Garschagen & Fernando, KROPP | *Natural Hazards*, | 55(3) | Springer | N/A | 2009 | 637-655 | doi: 10.1007/s11069-008-9319-2 | No |
| 6 | Spatial and temporal assessment of drought in the Northern highlands of Ethiopia | TAGEL, G., VAN DER VEEN, A., & Maathuis, B. | International Journal of Applied Earth Observation and Geoinformation | Vol. 13( 3), 309, 2011 | Elsevier Science | | 2011 | 309-321 | | yes |
| 7 | Effect of Policy | VAN DER VEEN, | Ecology and | 6(1 (18), | Resilience | Wolfvile, | 2011 | published | | yes |

| NO. | Title | Main author | Title of the periodical or the series | Number, date or frequency | Publisher | Place of publication | Year of publication | Relevant pages | Permanent identifiers[2] (if available) | Is/Will open access[3] provided to this publication? |
|---|---|---|---|---|---|---|---|---|---|---|
| | Interventions on Food Security in Tigray, Northern Ethiopia | A., & Gebrehiwot, T. | Society | 2011 | Alliance | Nova Scotia | | online: http://www.ecologyandsociety.org/vol16/iss1/art18/ | | |
| 8 | Resilience and/or vulnerability? Relationships and Roles in Risk Mitigation Strategies | A. GALDERISI (UNINA) | Selected Proceedings 24th Aesop Annual Conference 2010 | | Aalto University School of Science and Technology Centre for Urban and Regional Studies | Finland | 2010 | pp. 388-405 | Available at: http://lib.tkk.fi/Reports/2010/isbn9789526031309.pdf | yes |
| 9 | Threat of sea-level rise: costs and benefits of adaptation in European Union coastal countries | COSTA L, Tekken V, KROPP JP | *Journal of Coastal Research* | 56 | JRC | N/A | 2009 | 223-227 | N/A | No |
| 10 | Risks, vulnerability and needs for adaptation in climate sensitive regions | Stock M, KROPP JP, Walkenhorst O. | *Raumforschung und Raumordnung* | 67(2) | Bundesamt für Raumforschung | N/A | 2009 | 97-113 | N/A | yes |
| 11 | Explanatory notes of the Geomorphological map of the Alta Badia valley (Dolomites, Italy) | M. SOLDATI (Univ. of Modena for POLIMI) | Geografia Fisica e Dinamica Quaternaria | Vol. 34(1), June 2011 | Brigati Editore | Genova, Italy | 2011 | pp. 105-126 | http://gfdq.glaciologia.it/issues/ | No |
| | **Under review:** | | | | | | | | | |

| NO. | Title | Main author | Title of the periodical or the series | Number, date or frequency | Publisher | Place of publication | Year of publication | Relevant pages | Permanent identifiers[2] (if available) | Is/Will open access[3] provided to this publication? |
|---|---|---|---|---|---|---|---|---|---|---|
| 12 | Indirect identification of damage functions from damage records | Steinhäuser M, Rybski D, KROPP JP | *Geophysical Research Letters* | [under review] | American Geophysical Union | N/A | 2011 | N/A | N/A | No |
| 13 | Linking operations and definitions of vulnerability: Lessons from case studies in climate-change and risk-hazard context | COSTA L, KROPP JP (PIK) | *Sustainability Science* | [under review] | Springer | N/A | N/A | N/A | N/A | No |
| 14 | Developing and applying a methodological frame work to assess vulnerability to flash floods | S. MENONI, D. MOLINARI, F. Ballio, D. PARKER, S. TAPSELL | Natural Hazards | 3/year | Springer | Germany | 2011 (?) | | To be submitted in special issue EGU assembly 2011 | No |
| 15 | "Vulnerability Management by means of Resilience" | K. SAPOUNTZAKI (HUA) | Natural Hazards | Fully accepted but not printed yet | Springer | N/A | 2011 | Not known yet | Not yet available (the paper is at the proofreading stage (just before the "Online first" stage) | No |
| | **In Preparation:** | | | | | | | | | |
| 16 | Vulnerability of the semi-arid territorial systems to droughts | I. BENENSON, G. KIDRON, T. Zilberman, Y. Bakman (TAU) | Landscape and Urban Planning | In Preparation | Elsevier | | | | | No |
| 17 | Agent-based model of agriculture land | Y. Grinblat, I. BENENSON, G. | Ecological Modelling | In Preparation | Elsevier | | | | | No |

| NO. | Title | Main author | Title of the periodical or the series | Number, date or frequency | Publisher | Place of publication | Year of publication | Relevant pages | Permanent identifiers[2] (if available) | Is/Will open access[3] provided to this publication? |
|---|---|---|---|---|---|---|---|---|---|---|
| | use dynamics and its application for the Kita area, Mali | KIDRON (TAU) | | | | | | | | |

**TABLE A2: LIST OF DISSEMINATION ACTIVITIES**

| NO. | Type of activities[4] | Main leader | Title | Date | Place | Type of audience[5] | Size of audience | Countries addressed |
|---|---|---|---|---|---|---|---|---|
| 1 | Other (Meeting) | Evelyne FOERSTER (BRGM) | MOVE technical Kick-off meeting | 01-03/02/09 | Bonn, Germany | Scientific Community | 25 | EU countries |
| 2 | Other (Training) | Sue TAPSELL (MDX) | Professional training courses for UK Environment Agency staff | 5 in 2009: Jan., March, July, Sept. and Nov. | London | Policy makers | 80 | UK |
| 3 | Workshop | Hormoz MODARESSI (BRGM) | International workshop on Disaster Risk Reduction – organised by DG RTD / UN-ISDR | 29-30/10/09 | Brussels, Belgium | Scientific Community, Policy makers (with EC-DG RTD and UN-ISDR, and DDR National platforms) | 70-80 | EU countries |
| 4 | Other (Training) | Sue TAPSELL (MDX) | Foundation Degree in River and Coastal Engineering – 2 teaching modules | 27-29 October 2009 and 1-2 December 2009 | London and Bristol | Scientific Community | 120 | UK |
| 5 | Exhibition | Katja FIRUS, Fabrizio FASSIO (T6 ECO) | Civil protection Forum | 25/26 November 2009 | Brussels, Belgium | Policy Makers, Civil Society | 1000 | EU countries |
| 6 | Article published in the popular press | J. KROPP (PIK) | Climate Change: responses at regional level | 2009 | *Panorama* 31: 11 | | | EU countries |
| 7 | Article published in the popular press | J. KROPP (PIK) Scholze M (GIZ) | Climate Change Information for Effective Adaptation: A practitioner's manual | 2009 | Klarmann Druck, Kelheim, Germany, 57pp | | | International |
| 8 | Other (Training) | Edda PATTUZZI (Univ. of | PHD: FIRST YEAR | 22/01/2010 | Modena, Italy | Scientific | 50 | Italy |

[4] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[5] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias ('multiple choices' is possible.

| NO. | Type of activities[4] | Main leader | Title | Date | Place | Type of audience[5] | Size of audience | Countries addressed |
|---|---|---|---|---|---|---|---|---|
| | | Modena for POLIMI) | REPORT | | | Community | | |
| 9 | Other (Meeting) | Sue TAPSELL (MDX) | Meeting with Health Protection Agency in UK | 2 February 2010 | London | Policy makers | 2 | UK |
| 10 | Other (Meeting) | Sue TAPSELL (MDX) | Environment Agency and Department for the Environment, Food and Rural Affairs Joint Research and Development Programme Theme Advisory Group meeting | 4 February 2010 | London | Policy Makers | 10 | UK |
| 11 | Workshop | Prof. M. SOLDATI (Univ. of Modena for POLIMI) | MEETING WITH SWISS AND ROMANIAN COLLEAGUES | 03/03/2010 | Modena, Italy | Scientific Community | 10 | Italy, Switzerland, Romania |
| 12 | Other (training) | Scira MENONI (POLIMI) | CERM Master, course Introduction to risk management | 1st semester 2010 | Lecco, Italy | Master students | 30 | EU and third countries (Iran, India, Norway, etc.) |
| 13 | Presentation/Panel Discussion | J. KROPP (PIK) | Inv. Key note on ``Climate Change Challenges for India" High Tea Event of the Indian Forum of the Parliamentarians | 17. March 2010 | New Delhi | Member of Indian Parliament | 50 | India |
| 14 | Presentation (incl. discussion) | J. KROPP (PIK) | Climate Change & Planning Challengers | 4. July 2010 | Cologne | Expert Meeting/ Administration German Institute for regional planning | 60 | Germany |
| 15 | Conference | Adriana GALDERISI (UNINA) | XXIV AESOP Congress “Space is luxury”, | July 7-10, 2010 | Helsinki, Finland | Scientific Community | 80 (the single session) | Mainly European Countries |
| 16 | Other (Meeting) | Sue TAPSELL (MDX) | Start-up meeting of | 9-10 July 2010 | Leipzig, | Scientific | 20 | EU countries |

| NO. | Type of activities[4] | Main leader | Title | Date | Place | Type of audience[5] | Size of audience | Countries addressed |
|---|---|---|---|---|---|---|---|---|
| | | | the FP7 CapHaz-Net project | | Germany | Community | | |
| 17 | Workshop | Sue TAPSELL (MDX) | Natural Hazards Centre annual workshop | 16-19 July 2010 | Boulder, Colorado, USA | Scientific Community | 100 | International |
| 18 | Other | Evelyne FOERSTER (BRGM)<br>Claudio MARGOTTINI (for T6 ECO) | MOVE plenary meeting | 16-17/09/2010 | Bolzano, Italy | Scientific Community | 25 | EU countries |
| 19 | Presentation, Session Chair, Conference Summary | J. KROPP (PIK) | Int. Conf. on Climate Change & Development | 22 Oct. 2010 | Islamabad, Pakistan | Governmental/ Administration/ Science | 700 | Pakistan/ International |
| 20 | Presentation/Panel Discussion | J. KROPP (PIK) | Int. Conference on Natural Resource Management | 11 Nov. 2010 | Mahidol University, Bangkok/ Thailand | Science/ Administration | 100 | International |
| 21 | Presentation/Panel Discussion | J. KROPP (PIK) | Inception Mission on Adaptation to Climate Change in Pacific Island States | 17 Nov. 2010 | Suva/Fiji | Administration/ Governmental | 70 | South Pacific Islands States |
| 22 | Article published in the popular press | J. KROPP (PIK) | Flüchtlingsströme der Zukunft | 2010 | Bundeswehr Aktuell 46(38): 6 | | | Germany |
| 23 | Conference | Scira MENONI (POLIMI) | Evaluación de la vulnerabilidad y resiliencia a inundaciones y deslaves: marco teórico conceptual y aplicaciones en el proyecto Ensure-EU | 14-15 Feb. 2011 | Mexico City | Researchers and civil protection officials | 50 | Mexico, Colombia, USA, EU |
| 24 | Conference | Mauro SOLDATI (Univ. of Modena for POLIMI) | Poster entitled: *Geomorphological map of the Alta Badia Valley (Dolomites, Italy)* | 18-22 Feb. 2011 | Addis Ababa, Ethiopia | Scientific community | 200 | Worldwide |

| NO. | Type of activities[4] | Main leader | Title | Date | Place | Type of audience[5] | Size of audience | Countries addressed |
|---|---|---|---|---|---|---|---|---|
| 25 | Presentation (incl. discussion) | J. KROPP (PIK) | Inv. Key Note on Climate Risks and Challenges for Cities. | April 2011 | Hamburg State Residency in Berlin | Annual meeting of ambassadors and environmental experts | 40 | Europe |
| 26 | Conference | Amelie VAGNER (BRGM) | EGU2011 - presentation of a Poster in the Vulnerability session + general dissemination | 03-08/04/2011 | Vienna, Austria | Scientific Community | 30 | EU countries |
| 27 | Conference | Adriana GALDERISI (UNINA) | EGU2011 | 03-08/04/2011 | Vienna, Austria | Scientific Community | 40 (the single session) | European Countries |
| 28 | Conference (Session Chair) | J. KROPP (PIK) | *Session on EGU 2011,*NH5.5: Storm Surges and coastal areas: extreme events, damages, and risk | 03-08/04/2011 | Vienna, Austria | Scientific Community | 60 | International |
| 29 | Presentation | DE. Reusser, C. Luis, H. Förster, T. Lissner, CA. Pape, P. Pradhan, T. Sterzel, T. Weiß, M. Wrobel, J. KROPP (PIK) | Communication of climate change induced natural hazards with a web plattform | 2011 | *Geophysical Research Abstracts*: 13: EGU2011-6025 | Scientific Community | 50 | International |
| 30 | Presentation | L. COSTA, M. Meidinger, J. KROPP (PIK) | Adaptive pathways in coastal systems for losses reduction due to storm surges and sea-level rise: The case of Ísafjördur, Iceland | 2011 | *Geophysical Research Abstracts*: 13: EGU2011-8605-3. | Scientific Community | 30 | International |
| 31 | Presentation | M. Boettle, D. Rybski, J. KROPP (PIK) | A cost-benefit framework for adaptation to sea level rise | 2011 | *Geophysical Research Abstracts*: 13: EGU2011-343. | Scientific Community | 60 | International |
| 32 | Presentation | D. Rybski, M. Steinhäuser, J. | Identifying damage | 2011 | *Geophysical* | Scientific | 60 | International |

| NO. | Type of activities[4] | Main leader | Title | Date | Place | Type of audience[5] | Size of audience | Countries addressed |
|---|---|---|---|---|---|---|---|---|
| | | KROPP (PIK) | functions through density transformation. | | *Research Abstracts*: 13, EGU2011-289 | Community | | |
| 33 | Other (Training) | Scira MENONI (POLIMI) | CERG-C master course | 27 April and 20 May 2011 | Geneva, Switzerland and Vulcano (Italy) | PhD students and civil protection officials | 15 | EU and 3rd countries (USA; Colombia, etc.) |
| 34 | Workshop | All ENSURE partners | ENSURE Final workshop with the participation of MOVE | 10-11/05/2011 | Orléans, France | Scientific Community, Civil Society, EC representative | 70 | EU countries |
| 35 | Publication | J. KROPP, HJ. Schellnhuber (PIK) | In Extremis: Disruptive Events and Correlations in Hydrology and Climate | 2011 | Springer, Berlin, 320pp. | | | |
| | **After the end of the project:** | | | | | | | |
| 36 | Conference | J. KROPP (PIK) | Inv. Key note on Resilient Cities 2011: Resilient cities: Just a sales pitch or a well-defined concept to cope with climate change? | 4 June 2011 | Bonn | Science & Stakeholder 30/70% | 400 | International |
| 37 | Conference | S. KUNDAK, F. ATUN, G. Minucci (for POLIMI) | 20th SRA-Europe Meeting | 5-8 June 2011 | Stuttgart, Germany | Scientific community | 300 | International (34 countries including Rep. of Korea, Canada, USA, Japan, Australia and China) |
| 38 | Workshop | Kalliopi SAPOUNTZAKI | FOKO Colloquium, | 7 July 2011 | Dortmund, | Researchers, | 20 | Germany and |

| NO. | Type of activities[4] | Main leader | Title | Date | Place | Type of audience[5] | Size of audience | Countries addressed |
|---|---|---|---|---|---|---|---|---|
| | | (HUA) | IRPUD, School of Spatial Planning, Technical University of Dortmund | | Germany | post-graduate students | | other EU countries |
| 39 | Thesis | MSc. D. Sietz; PhD Commission Chair: Prof. J. KROPP (PIK) | Dryland vulnerability - Typical patterns and dynamics in support of vulnerability reduction efforts | summer 2011 | Potsdam | PhD Defence | Approx. 30 | Germany |
| | **In the near future:** | | | | | | | |
| 40 | Conference | Adriana GALDERISI (UNINA) | The 2nd World Landslides Forum (*paper reviewed and accepted*) | October 2011 | Rome | Scientific Community | 1000 expected | International |
| 41 | Conference | Sue TAPSELL (MDX | 5th Int. Conf. on Flood Management | 27-29 Sept. 2011 | Tokyo, Japan | Scientific Community | 300-400 expected | International |
| | | | | | | | | |

**Section B (Confidential[6] or public: confidential information to be marked clearly)**
**Part B1**

The applications for patents, trademarks, registered designs, etc. shall be listed according to the template B1 provided hereafter.

The list should, specify at least one unique identifier e.g. European Patent application reference. For patent applications, only if applicable, contributions to standards should be specified. This table is cumulative, which means that it should always show all applications from the beginning until after the end of the project.

| **TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.** | | | | | |
|---|---|---|---|---|---|
| Type of IP Rights[7]: | Confidential Click on YES/NO | Foreseen embargo date dd/mm/yyyy | Application reference(s) (e.g. EP123456) | Subject or title of application | Applicant (s) (as on the application) |
| | | | | | |

[6] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

[7] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

**Part B2**
Please complete the table hereafter:

| Type of Exploitable Foreground[8] | Description of exploitable foreground | Confidential Click on YES/NO | Foreseen embargo date dd/mm/yyyy | Exploitable product(s) or measure(s) | Sector(s) of application[9] | Timetable, commercial or any other use | Patents or other IPR exploitation (licences) | Owner & Other Beneficiary(s) involved |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

In addition to the table, please provide a text to explain the exploitable foreground, in particular:

- Its purpose
- How the foreground might be exploited, when and by whom
- IPR exploitable measures taken or intended
- Further research necessary, if any
- Potential/expected impact (quantify where possible)

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.
[9] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

## 4.3 Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

| **A General Information** *(completed automatically when **Grant Agreement number** is entered.* | |
|---|---|
| **Grant Agreement Number:** | 212045 |
| **Title of Project:** | Enhancing resilience of communities and territories facing natural and na-tech hazards (ENSURE) |
| **Name and Title of Coordinator:** | Prof. Hormoz MODARESSI, Head of the Risks Division, BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES, BRGM |

| **B Ethics** | |
|---|---|
| **1. Did your project undergo an Ethics Review (and/or Screening)?**<br><br>* If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports?<br><br>Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'* | ***No*** |
| **2. Please indicate whether your project involved any of the following issues (tick box) :** | |
| **RESEARCH ON HUMANS** | |
| * Did the project involve children? | No |
| * Did the project involve patients? | No |
| * Did the project involve persons not able to give consent? | No |
| * Did the project involve adult healthy volunteers? | No |
| * Did the project involve Human genetic material? | No |
| • Did the project involve Human biological samples? | No |
| • Did the project involve Human data collection? | No |
| **RESEARCH ON HUMAN EMBRYO/FOETUS** | |
| * Did the project involve Human Embryos? | No |
| * Did the project involve Human Foetal Tissue / Cells? | No |
| * Did the project involve Human Embryonic Stem Cells (hESCs)? | No |
| * Did the project on human Embryonic Stem Cells involve cells in culture? | No |
| * Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos? | No |
| **PRIVACY** | |
| * Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)? | No |
| * Did the project involve tracking the location or observation of people? | No |
| **RESEARCH ON ANIMALS** | |
| * Did the project involve research on animals? | No |

| | |
|---|---|
| * Were those animals transgenic small laboratory animals? | No |
| * Were those animals transgenic farm animals? | No |
| * Were those animals cloned farm animals? | No |
| * Were those animals non-human primates? | No |
| **RESEARCH INVOLVING DEVELOPING COUNTRIES** | |
| * Did the project involve the use of local resources (genetic, animal, plant etc)? | No |
| * Was the project of benefit to local community (capacity building, access to healthcare, education etc)? | No |
| **DUAL USE** | |
| • Research having direct military use | No |
| * Research having the potential for terrorist abuse | No |

## C Workforce Statistics

**3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).**

| Type of Position | Number of Women | Number of Men |
|---|---|---|
| Scientific Coordinator | 7 | 2 |
| Work package leaders | 4 | 3 |
| Experienced researchers (i.e. PhD holders) | 13 | 21 |
| PhD Students | 4 | 7 |
| Other | 9 | 6 |

| | |
|---|---|
| **4. How many additional researchers (in companies and universities) were recruited specifically for this project?** | **13** |
| Of which, indicate the number of men: | 7 |

## D Gender Aspects

| | | |
|---|---|---|
| **5. Did you carry out specific Gender Equality Actions under the project?** | ○ X | Yes No |

**6. Which of the following actions did you carry out and how effective were they?**

| | | Not at all effective | | | | Very effective |
|---|---|---|---|---|---|---|
| ❑ | Design and implement an equal opportunity policy | ○ | ○ | ○ | ○ | ○ |
| ❑ | Set targets to achieve a gender balance in the workforce | ○ | ○ | ○ | ○ | ○ |
| ❑ | Organise conferences and workshops on gender | ○ | ○ | ○ | ○ | ○ |
| ❑ | Actions to improve work-life balance | ○ | ○ | ○ | ○ | ○ |
| ○ | Other: | | | | | |

**7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?**

○ Yes- please specify

X No

## E Synergies with Science Education

**8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?**

X Yes- please specify: Lectures and presentations have been made in Universities and a tabletop emergency exercise has been organised with elementary and middle schools

○ No

**9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?**

X Yes- please specify: E-learning tool and presentations

○ No

## F Interdisciplinarity

**10. Which disciplines (see list below) are involved in your project?**

X Main discipline[10]: 1.4

X Associated discipline[10]: 5.4

X Associated discipline[10]: 5.2

## G Engaging with Civil society and policy makers

| | | |
|---|---|---|
| **11a Did your project engage with societal actors beyond the research community?** *(if 'No', go to Question 14)* | X ○ | Yes No |

**11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?**

○ No

X Yes- in determining what research should be performed

[10] Insert number from list below (Frascati Manual).

| | |
|---|---|
| X | Yes - in implementing the research |
| x | Yes, in communicating /disseminating / using the results of the project |

| | | | |
|---|---|---|---|
| **11c** | **In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?** | **X**<br>**○** | **Yes**<br>**No** |

**12. Did you engage with government / public bodies or policy makers (including international organisations)**

| | |
|---|---|
| ○ | No |
| X | Yes- in framing the research agenda |
| X | Yes - in implementing the research agenda |
| X | Yes, in communicating /disseminating / using the results of the project |

**13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?**

| | |
|---|---|
| X | Yes – as a **primary** objective (please indicate areas below- multiple answers possible) |
| ○ | Yes – as a **secondary** objective (please indicate areas below - multiple answer possible) |
| ○ | No |

**13b If Yes, in which fields?**

| | | | | | |
|---|---|---|---|---|---|
| Agriculture | x | Energy | | Human rights | |
| Audiovisual and Media | | Enlargement | | Information Society | |
| Budget | | Enterprise | | Institutional affairs | |
| Competition | | Environment | x | Internal Market | |
| Consumers | | External Relations | | Justice, freedom and security | |
| Culture | | External Trade | | Public Health | |
| Customs | | Fisheries and Maritime Affairs | | Regional Policy | |
| Development Economic and Monetary Affairs | | Food Safety | | Research and Innovation | |
| | | Foreign and Security Policy | | Space | |
| Education, Training, Youth | | Fraud | | Taxation | |
| Employment and Social Affairs | | Humanitarian aid | | Transport | |

**13c If Yes, at which level?**

- X Local / regional levels
- X National level
- ○ European level
- ○ International level

## H Use and dissemination

| | |
|---|---|
| **14. How many Articles were published/accepted for publication in peer-reviewed journals?** | **13** |
| **To how many of these is open access[11] provided?** | **4** |
| **How many of these are published in open access journals?** | **2** |
| **How many of these are published in open repositories?** | **4** |
| **To how many of these is open access not provided?** | **11** |
| **Please check all applicable reasons for not providing open access:** | |
| x publisher's licensing agreement would not permit publishing in a repository<br>❑ no suitable repository available<br>x no suitable open access journal available<br>x no funds available to publish in an open access journal<br>❑ lack of time and resources<br>x lack of information on open access<br>x other[12]: Open access journal are not so highly ranked than others (quality measures) | |

| | | |
|---|---|---|
| **15. How many new patent applications ('priority filings') have been made?** *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).* | | **0** |
| **16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).** | Trademark | **0** |
| | Registered design | **0** |
| | Other | **0** |
| **17. How many spin-off companies were created / are planned as a direct result of the project?** | | **0** |
| ***Indicate the approximate number of additional jobs in these companies:*** | | |

**18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:**

| | | | |
|---|---|---|---|
| ❑ | Increase in employment, or | ❑ | In small & medium-sized enterprises |
| x | Safeguard employment, or | ❑ | In large companies |
| ❑ | Decrease in employment, | x | None of the above / not relevant to the project |
| ❑ | Difficult to estimate / not possible to quantify | | |

[11] Open Access is defined as free of charge access for anyone via Internet.
[12] For instance: classification for security project.

| | |
|---|---|
| **19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (FTE = one person working fulltime for a year) jobs:** | *Indicate figure:* 10 |
| Difficult to estimate / not possible to quantify | ❑ |

## I Media and Communication to the general public

**20. As part of the project, were any of the beneficiaries professionals in communication or media relations?**

○ Yes x No

**21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?**

○ Yes x No

**22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?**

| | | | |
|---|---|---|---|
| x | Press Release | x | Coverage in specialist press |
| ❑ | Media briefing | x | Coverage in general (non-specialist) press |
| ❑ | TV coverage / report | ❑ | Coverage in national press |
| ❑ | Radio coverage / report | ❑ | Coverage in international press |
| x | Brochures /posters / flyers | x | Website for the general public / internet |
| x | DVD /Film /Multimedia | x | Event targeting general public (festival, conference, exhibition, science café) |

**23 In which languages are the information products for the general public produced?**

| | | | |
|---|---|---|---|
| ❑ | Language of the coordinator | x | English |
| ❑ | Other language(s) | | |

***Question F-10*:** Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

**FIELDS OF SCIENCE AND TECHNOLOGY**

1. NATURAL SCIENCES
1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]
1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)
1.3 Chemical sciences (chemistry, other allied subjects)
1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)
1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY
2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)
2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]