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Introduction

The notions of "territory" and "territoriality" have undergone a noticeable change from a static view to a more dynamic approach, which stresses the concept of territory as a social and political construction and or as a spatial entity possessing territorial capital. It is no longer sufficient to assume that "all social relations are organized within self-enclosed, discreetly bounded territorial containers", i.e. to endorse the "methodological territorialism" approach, to use Neil Brenner's words (Brenner 2004, 38). It is more productive to view the territorial unit as one which has been the product of a complex set of forces, i.e. a "social and political construction", which has produced a particular form of "territorial capital". In the ESPON Glossary, appended to the final report of ESPON project 3.1, reference is made to a definition of "territory" as an "appropriate space": "Whatever be the scale taken into consideration, Europe, State, Region, Village, it has been built either by history or by institutions or else by collective logics, or by all these elements together. It implies a notion of identity, authority and, increasingly, a notion of planning" (ESPON project 3.1 2004).

The governance of a territorial unit and the protection and development of its territorial capital require collective action, going beyond the traditional public administration initiatives. The notion of territory which we propose to adopt follows the analysis of the final report of the European Commission's ESPON 2.3.2 project of territorial governance, of which we quote here an extract.

> "According to a wide international literature … territory is a complex concept. It can be considered as a complex set of values and resources, a common good of fixed assets, material and immaterial, an exhaustible resource, a political and economic 'fact', a 'social construction' deriving from the collective action of groups, interests and institutions … The main definitions of territory that allow to deal with the issues highlighted in the international debate on governance are: the territory as a 'social and political construction' and the territory as 'territorial capital'" (ESPON project 2.3.2 2006, ch. 1.3).
>
> "According to Bagnasco and Le Galès (2000), the concept of the territory as a 'social and political construction' mainly stresses the collective action, that is the actions, undertaken by a set of actors, that are related to the solution of a collective problem. The collective action springs from groups, organised interests and territorial institutions mobilisation, in a process in which actors' interactions can lead to different results (confrontation, cooperation, conflict)" (ESPON project 2.3.2 2006, ch. 1.3).

Camagni identifies, from an economic point of view, the notion of territory as an asset, i.e. as capital, which is simultaneously:

- "A system of localized 'technological' externalities;
- A system of localized know-how (historical productive 'vocations');

- A system of economic and social relations (*relational capital* or *social capital*) resulting in a reduction of risks, transaction costs, uncertainty in innovation processes, facilitation of 'collective actions' by private actors;
- A system of local governance, resulting in easier implementation of local strategies and more efficient bargaining processes with external firms" (Camagni 2005).

Our approach also draws on the analysis of the concept of "territorial cohesion", now incorporated in the draft of the Lisbon Treaty of the European Union. Territorial cohesion, as Davoudi (2005) has remarked, implies, among others, the protection of a territorial unit's welfare, somewhat like the protection of the social welfare of individual citizens, embodied in the policy of social cohesion. In other words, as we aim, through a policy of social cohesion, at protecting individual citizens, from the vagaries and fluctuations of the free market, so that, within a given territory, they all enjoy the same social protection, we should also aim, through a policy of *territorial* cohesion, at protecting each territorial unit and place, by enhancing and maximizing its potentialities, i.e its *territorial* capital (Wassenhoven 2008, 254). It follows that "territorial vulnerability" can be viewed as a condition affecting these potentialities, i.e. all the elements of territorial capital. This allows a freedom of analysis extending beyond mere "physical" vulnerability and encompassing all aspects of territorial vulnerability.

The concepts of territorial vulnerability and territorial capital will be discussed further in the sections on objectives and on conceptual approaches. Territorial vulnerability is a concept virtually unknown and unused in the literature. In the introduction, we limit ourselves to quoting Wisner *et al*. (2004) on vulnerability and then Cutter on a notion akin to territorial vulnerability.

> "By vulnerability we mean *the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard* (an extreme natural event or process). It involves a combination of factors that determine the degree to which someone's life, livelihood, property and other assets are put at risk by a discrete and identifiable event (or series or 'cascade' of such events) in nature and in society" (Wisner *et al*. 2004, 11) (Italics in the original).

The failure to link vulnerability and territory is surprising, all the more so since Susan Cutter had introduced her "hazards of place model of vulnerability" as far back as 1996, a model with a clear territorial conception. As she put it, "while vulnerability as potential exposure or social response pervades the literature, a third dimension is emerging that combines elements of the two, but which is inherently more geographically centred. In this perspective, vulnerability is conceived as both a biophysical risk as well as a social response, but within a specific areal or geographic domain. This can be geographic space, where vulnerable people and places are located, or social space, who in those places are most vulnerable [sic]" (Cutter 1996, 533).

Territorial capital is a novel concept on which little has been written so far. Camagni refers to it as a concept "that, strangely enough, has only recently made its appearance, and has done so outside a strictly scientific context" (Camagni 2007, 3). A most quoted definition is that given in an OECD (Organization for Economic Co-operation and Development) report, in a comment on the factors determining territorial capital:

> "These factors may include the area's geographical location, size, factor of production endowment, climate, traditions, natural resources, quality of life or the agglomeration economies provided by its cities, but may also include its business incubators and industrial districts or other business networks that reduce transaction costs. Other factors may be 'untraded interdependencies' such as understandings, customs and informal rules that enable economic actors to work together under conditions of uncertainty, or the solidarity, mutual assistance and co-opting of ideas that often develop in clusters of small medium-sized enterprises working in the same sector (social capital). Lastly, according to Marshall, there is an intangible factor, 'something in the air', called the 'environment' and which is the outcome of a combination of institutions, rules, practices, producers, researchers and policy-makers, that make a certain creativity and innovation possible" (OECD 2001, 15-16).

In this document we espouse the view that the parameters used in the definitions of vulnerability and territorial capital have a great deal of similarity which can prove fruitful in the analysis of *territorial* vulnerability. The components of territorial capital, if appropriately identified, can be shown to constitute not only an area's development potentialities and ability to grasp opportunities, but also its capacity to cope with, and successfully counter, adversities generated by external shocks. Hence, they can explain its fragility in the face of risk and/or its readiness to overcome disasters and recover from damage and stress. Territorial capital is a shield against vulnerability, but, inversely, its deficiencies and/or inadequacies are conducive to territorial structural weakness and vulnerability. The challenge is therefore to formulate territorial capital conceptually and operationally in a manner which serves the analysis of territorial vulnerability.

1.1 Objectives

The present review does not attempt to exhaust the list of authors that have used the term vulnerability and *Territorial Vulnerability* in particular (besides territorial vulnerability is not yet a popular term). Neither does it intend to analyze at length the numerous interpretations of the term one by one. Such a task would necessitate an extremely lengthy report, long time and costly efforts. Such a report has been produced by Villagrán de León (2006). In any case it would not serve the principal objective of this project, i.e. the construction of an integral and holistic operational framework to localize and spatialize vulnerability to natural / environmental hazards and contain or control the root causes and underlying mechanisms which set in motion the production and transference of vulnerability.

Therefore, the present review aims instead at:

(a) Grouping the conceptual approaches to vulnerability (territorial vulnerability in particular) in order to identify major lines of thought or epistemological paradigms;
(b) Presenting in detail and criticizing representative or "original" methodological examples of the above paradigms; these original cases are selected on the basis of one or more of the following criteria:
    - They are widely known or enjoy some sort of supra-national, European or international acceptance and consensus (e.g. they are the product of research of international or EU organizations);
    - They have produced theoretical formulas which have been tested and/or applied by using as input reliable statistical datasets to yield tools useful for risk management policies;
    - They are up-to-date refined versions of older approaches;

- They are approaches resulting from recent research work carried out by the partners of ENSURE or generally the research communities of the respective countries.

The explicit use of the term *Territorial Vulnerability* has not been a strict and binding condition for the eligibility of the cases selected as examples. It has been considered that pertinent terms, such as *Regional Vulnerability, urban vulnerability, area vulnerability geographical vulnerability, vulnerability of place, vulnerability of neighbourhood, district, a human-ecological system* etc. denote socio-spatial units approximating more or less the concept of territory.

Apart from the general and principal objectives of the review, its structure and content serves and reflects a whole series of more specific targets:

1. To collect and present both hazard-specific and non hazard-specific approaches and empirical methodologies; in the latter case to include methodologies representing the widest possible range of hazards;
2. To criticize approaches and methodologies in terms of their appropriateness, reliability, inclusiveness, feasibility, specificity, applicability, effectiveness, usability, efficiency and simplicity as tools for risk policies;
3. To address interrelations and interdependencies between territorial and other versions of vulnerability (i.e. physical, socio-economic, ecological, systemic, institutional);
4. To search for interrelationships between territorial vulnerability and other relevant attributes and concepts, like exposure, resilience, adaptive capacity, coping capacity etc.;
5. To search for the multiple dimensions and forms of territorial vulnerability with respect to the types of potential losses, timing of vulnerability occurrence as regards the phases of the disaster cycle, spatial scales of reference etc.; furthermore to reveal how the dimensions and forms of territorial vulnerability are integrated or possibly combined with each other;
6. To investigate the dynamics of territorial vulnerability, i.e. its transformation to other versions, transference to other territories or non-spatial agencies, increase of future vulnerability for the sake of reduction of present vulnerability and so on.

Responding to the above targets the Chapter on territorial vulnerability has been structured to include:

- a sub-chapter on conceptual approaches referring basically to the major epistemological paradigms (sub-chapter 1.2);
- a sub-chapter on concrete and applied methodologies –indicative of the prevailing paradigms- that incorporates both the description / presentation of the methodologies and critical comments (sub-chapter 4.3);
- a sub-chapter on special cases of geographical space calling for particular attention (insular and remote areas, zones and areas vulnerable to Na-techs and other multi-risk situations, natural areas and built areas or settlements of environmental, historical, architectural value, especially those designated as protected, illegal land developments etc); also on specific territorial issues affecting vulnerability, such as territorial dynamism, wider spatial influence (administrative, economic, social, symbolic) of particular areas, the potential to attract and mobilize external resources, land market dynamics, development pressures and urban decline, also planning and building regulations and interventions that impact on territorial vulnerability (sub-chapter 4.4);

- a sub-chapter dedicated to the strong relationship between institutional and territorial vulnerability with special interest in vulnerabilities of *Emergency Response and Relief Mechanisms, Institutions and Processes for Recovery and Reconstruction, Formal and Informal Insurance and Assistance Mechanisms* and the perceptions of vulnerability by the public administrations, the political elites and civil society (sub-chapter 4.5); and finally
- a sub-chapter addressing the interactions and relationships (or overlaps) between territorial and other versions of vulnerability (sub-chapter 4.6).

The importance of the spatial scale of reference has been acknowledged by dividing the sub-chapter on "Identity of Methodologies" (4.3) into four paragraphs addressing separately methodologies at Regional, Functional Urban Area, Neighbourhood and Building Block level. Special attention to the hazard type is not reflected in the structure of the Chapter because several of the methodologies are non-hazard specific or refer to groups of hazards.

The present chapter, on vulnerability of territorial systems, is expected to outline the theoretical and experimental advancements regarding conceptualization, interpretation and evaluation of territorial vulnerability for the purpose of improving vulnerability coping strategies at international, European, national, regional and local level. In simple words this means that grading, indexing, and mapping relative vulnerability levels is far from sufficient; what is actually needed is to reveal and localize the root causes, producing mechanisms and spatial and temporal routes of vulnerability. Failing to do this, the study will capture only the symptoms of vulnerability and will not contribute to combat the always existing but aggravating fragility of contemporary territories.

Our ambition in this project is to move beyond the confines of past research and the existing conceptualization of vulnerability, by exploring its *territorial* dimension and the links of the latter with environmental, economic, social, institutional and other vulnerabilities. We firmly believe that for this purpose we must open our research horizon to other social science fields, which have turned their interest to the investigation of territoriality and territorial relations. By doing so we can bring into the study of vulnerability, in particular territorial vulnerability, a wealth of theoretical concepts, tools of analysis and methods, which are the product of scientific work in human geography and spatial studies.

In order to further our understanding of territorial vulnerability, provide support to its conceptual validity and enrich its content, we explore among others the use of the notion of territorial capital. Admittedly, this too is a fairly new and little explored concept. But it has the advantage of having originated from a rich field of theoretical studies on "space", not as a static, descriptive concept, but as a dynamic factor of sustainable economic and social development. The spatiality of human activity is now viewed in a territorially systemic perspective, which looks at "space" as a system that amounts to much more than the sum of its constituent elements. In operational and policy-making terms, it is now accepted that public and non-public interventions must be placed in a territorial context if they are to be better integrated, coherent and coordinated. The recent emphasis in European Union policy on the importance of territoriality and on the slogan that "Geography Matters" is not just a matter of terminological innovation, but rather recognition of the economic, social, environmental, cultural and symbolic importance of space. This policy orientation is best illustrated by the emphasis on territorial governance and on territorial cohesion, now given equal status with economic and social cohesion.

We consider it therefore an important objective of our effort to explore territorial vulnerability to exploit to the full the possibility of using the concept of territorial capital, its content and components as an analytical and subsequently operational tool. As mentioned in the introduction, we need a reformulation of the concept, which was originally conceived in relation to development prospects and potential, to suit the needs of conceptualizing, measuring and operationalizing territorial vulnerability. More specifically, we must examine and redefine first and foremost the components of territorial capital from a vulnerability perspective.

However, before deliberating about the relations between vulnerability and territorial capital it is necessary to trace the paths and advancements of vulnerability conceptualization and assessment, particularly those referring to *space, place* and other alternatives of *territory* at all possible scales and levels (international, supra-national, national, regional, urban, local, district, neighbourhood etc).

1.2 Conceptual Approaches to Territorial Vulnerability

1.2.1 Schools of vulnerability definition and content

Despite sustained efforts to understand, defining and assess vulnerability the term remains uncertain and ambiguous as regards its meaning and operational content. This is evident by the fruitless efforts of numerous authors to arrive at a consensual definition and by the discrepancies among the descriptions and analyses of the constituent elements of vulnerability. Timmermann (1981) posited that "vulnerability is a term of such broad use to be almost useless for careful description at the present, except as a rhetorical indicator of areas of concern". According to Fussel and Klein (2006) important conceptual and semantic ambiguities and disagreements refer to the following queries:

- ✓ Whether vulnerability is a static or a dynamic concept;
- ✓ Whether it is an inherent property of a system (independent of the external threat) or contingent upon a specific scenario of external stresses and internal responses;
- ✓ Whether it should be defined in relation to an external stressor or in relation to an undesirable outcome (i.e. specific types of losses);
- ✓ Whether vulnerability should be the starting point, an intermediate element or the outcome of an assessment.

One could add some more queries such as:

- ✓ Whether vulnerability can be assessed by quantitative procedures and what then would be the use of and benefits from the relevant numerical results; or
- ✓ What are the processes and agencies producing, transferring and carrying vulnerability; or
- ✓ How does vulnerability changes and moves in time and space (given that it is a dynamic condition) (Sapountzaki 2005); or
- ✓ How vulnerability of upper levels relates to vulnerability of lower levels; or how vulnerability of recovery periods relates to past (pre-disaster and emergency vulnerabilities) and future vulnerabilities (i.e. pre-disaster in connection to the next catastrophic event).

Fussel and Klein (2006) by recalling Liverman's words (1990) and extending his line of thought note that "vulnerability has been related or equated to concepts such as resilience, marginality, susceptibility, adaptability, fragility, risk, exposure, sensitivity, coping capacity and criticality". Of the very many definitions one can find in the

international literature (Musser 2002; Villagrán de León 2006) the following might be selected as covering well the case of territorial vulnerability:

- *"The propensity of a society to experience substantial damage, disruption and casualties as a result of hazard"* (OECD-DAC 1994).
- *"Vulnerability concerns the complex of social, economic and political considerations in which peoples' everyday lives are embedded and that structure the choices and options they have in the face of environmental hazards…"* (Bolin and Stanford 1998).
- *"The level of exposure of human life, property and resources to damage from natural hazards"* (NOAA - Coastal Services Center n.d.).
- *"A system's susceptibility to change as a consequence of an extreme event"* (Sarewitz and Pielke 2000).
- *"The degree to which a system is sensitive to and unable to cope with adverse impacts of global change stimuli. Vulnerability is therefore a function of a system's exposure to global change stimuli and its adaptive capacity, that is its ability to cope with these stimuli"* (Potsdam Institute for Climate Impact Research, project EVA, 2004).
- *"The degree of susceptibility to a natural hazard"* (Lewis 1999).
- *"An aggregate measure of exposure to risk and its consequences"* (University of Oxford, Report of the Seminar on Vulnerability, 2000).
- *"Vulnerability analysis and assessments select a particular group or unit of concern (e.g. boreal forest ecosystems, coastal communities etc) and seek to determine the risk of specific adverse outcomes of that unit in face of the variety of stresses and to identify a range of factors that may reduce response capacity and adaptation to stressors"* (Potsdam Institute for Climate Impact Research 2002).

Fussel and Klein (2006) suggest that despite differences one can distinguish three basic models or schools of vulnerability conceptualization and assessment:

1. The first is consistent with the *Risk-Hazard* methodological framework or rationale and is characteristic of the technical literature on risk and disaster management. It conceptualizes vulnerability as the dose-response relationship between an exogenous hazard to a system and its adverse effects (see also UNDHA 1993; Dilley and Boudreau 2001; Downing and Patwardham 2003).
2. The second is the model of *Social Constructivism* and prevails in Political and Human Geography. It views (social) vulnerability as an a priori condition of a household or a community that is determined by socio-economic or political factors (Dow 1992; Blaikie et al. 1994; Adger and Kelly 1999). The studies following this line of thought connect vulnerability with a causal structure (beyond control by the individual social agencies) that explains the differential abilities of communities to cope with external stress. Vulnerability according to this view, seen as the socio-economic origin of differential sensitivity and exposure, corresponds to the non-biophysical factors of the disaster process.
3. The third model is most prominent in *climate change research*. Vulnerability according to this school includes an external dimension –which is represented by the "exposure" of a system to climate variations- as well as an internal one which comprises the system's sensitivity and adaptive capacity to external stressors (such as climate extremes). A distinctive example of this school of thought is the *"Hazard of Place"* model by Cutter (1996), a model which aims to integrate biophysical and social determinants of vulnerability.

In 1996 Cutter had adopted a similar taxonomy of vulnerability approaches, one that is focused on the probability of exposure (be it biophysical or technological), another that focuses on the probability of adverse consequences and a third that combined the first two options (i.e. the *Hazard of Place* model).

Indeed it seems that the first school puts emphasis on exposure either as the principal element of vulnerability (almost identical with it), or as the pre-condition, i.e. triggering factor for vulnerability to manifest itself. In the latter case exposure and vulnerability (a purely technical or physical issue) are independent from each other and interact with a hazard intervening to generate adverse impacts and losses.

The second school on the contrary (of social constructivism) views exposure as a consequence or an implication of social vulnerability which is the root cause, the origin of both exposure and disaster outcomes (risk). (Social) vulnerability precedes and high exposure or low resistance follows as an inevitable outcome. In this sense vulnerability is independent from the hazard, it is not hazard-specific, it is due to the prevailing socio-economic and political relations and structures either local or national, or international. On the other hand exposure is dependent on vulnerability, it is a function of social vulnerability; however the reverse is not valid, i.e. vulnerability is not a function of exposure. Exposure comes as the aftermath of vulnerability.

The third school of vulnerability conceptualization is familiar to geographers and focuses interest on localities and places. It is also familiar to Climate Change scientists. In particular it considers a place as an indivisible unity of the biophysical, social and cultural elements of a specific geographical region or territory, an undivided package of attitudes towards a potential threat. Therefore, the hazard potential is filtered through the geographic context and the social fabric of the local community to produce “Place Vulnerability”. The ultimate result is either moderation or exacerbation of the hazard potential (i.e. risk). The intermediate catalytic factor of this process is vulnerability. Hence, vulnerability is a function and the integrated outcome of exposure, sensitivity and adaptive capacity of a locality or a territorial unit. It refers mostly to geographic contexts, to climate change hazards, to a broad range of impacts and losses.

1.2.2 The “land-use planning” oriented approach (by UNINA and POLIMI)

Closely related to the above third school of vulnerability is a group of other approaches, which are still focused on localities and places, but are specifically grounded on the viewpoint of the land use planner. As a consequence they address those aspects of the vulnerability which are amenable exclusively through land use planning at different scales. They are mostly to be found in some European and Italian research Projects, such as the Armonia Project (Applied Multirisk Mapping of Natural Hazards for Impact Assessment – 2004-2007), the Interreg IIIB SISMA Project (Systems Integrated for Security Management Activities – 2004-2007) or the Italian Project “The safeguard of historical, landscape and cultural values in the Italian seismic areas” (2002-2004).

The above projects share the following basic positions and assumptions:

- There is a need to identify vulnerability parameters that are measurable (even though not always quantitatively, at least semi-quantitatively).

- There is a need to clarify how vulnerabilities transform into damages when the severe extreme event occurs.

- The multidimensional character of the concept of vulnerability as encompassing the full range of physical, functional, economic, social and cultural factors, is at present widely recognized by the international scientific community, but definitions and investigation methods are still very heterogeneous, according to different scales of analysis and specific targets of study.

- There exists a relevant strong link and connection between physical components of the built environment and other social, economic and administrative ones.

- A spatial planning approach contributes to devising methods and techniques for risk analysis and to move the focus from the relation between hazard and vulnerability of individual buildings or infrastructures towards the multiple aspects of the vulnerability of a city or a territory, which can be more directly tackled by spatial planning.

- A common point of the planners' approach to the concept of vulnerability is the interpretation of cities and territories as complex, spatial systems. That interpretation shifts attention from the individual elements of urban and territorial systems to the organization of the system itself. In the field of risk analysis, such an interpretation has led to focus on the role that the features of spatial and functional organization of urban and territorial systems may have on their propensity to be damaged by hazardous events. The concept of damage was accordingly enlarged from immediate physical damage to long and medium term functional and socioeconomic dislocation.

- It is widely accepted that there is a need of understanding how non physical variables influence physical vulnerabilities.

- Urban and territorial systems can be interpreted as "performance" systems, which have to supply specific services and satisfy the demand of communities. In the field of risk analysis this calls for a focus on the potential loss of efficiency of urban and territorial systems, i.e. on the loss or reduction of the capability of a system to supply with ordinary and extraordinary services a community hit by an hazardous event.

For their research work, which is presented in this chapter in parallel with the respective work of POLIMI, the research group of the Department of Urban and Regional Planning of the University of Naples Federico II (UNINA), relied on the following inputs from prior theoretical analysis, which helped them to build an approach to urban and territorial systems' vulnerability, with the specific aim to support land use planning strategies:

- The Banerjee studies on the impact of earthquakes on the urban systems (1982). Banerjee stressed the possible connections among the physical and spatial characteristics of an urban system and its capacity of preventing the disaster produced by the seismic impact. He underlined that "cities have been designed with all kinds of goals in mind (….) but there is no record of a city ever being designed to minimize earthquake disasters" (Banerjee, 1982). So he identified resiliency, interpreted as the ability to absorb shocks, "as a

theoretical goal for city design". Furthermore, although pointing out that "it may not be possible to specify any particular urban form which maximizes the goal of resiliency", he suggested some indicators pertaining "to the built characteristics of the physical place itself, others concerning the characteristics of people who inhabit or use the physical place", e.g. system redundancy, restorability, serviceability, occupancy, coping ability, critical residents. These indicators were defined both as performance characteristics of a resilient place, and as useful tools "to determine city wide priorities and policy measures". Other studies followed expanding further Banerjee's work on indicators and providing a clearer distinction between indicators related to physical vulnerability of settlements (characteristics of urban form, accessibility etc) and indicators of functional vulnerability (e.g. redundancy / replaceability or the presence of critical elements), interpreted as tendency of the urban system "to not fully and rightly accomplish its function also without any damage to one or more elements constituting it" (Fera, 1991). Urban vulnerability was also assumed to include socio – economic aspects, such as the level of emergency training, social cohesion, the capability of economic system recovery etc.

- The Italian studies related to the characteristics of urban and territorial systems and to the concept of entropy (Di Sopra et al., 1981). The authors proposed an interpretation of hazardous events as external stresses able to produce an "exceptional" quantity of energy, which represents an "anomalous" input to the system itself. Hence, according to the capacity of the system to face the input induced by the event, the entropy (seen as a measure of a system order) within the system will increase or decrease and, therefore, the loss of organization of the system will be minor or major. Starting from this systemic view and from a "performance approach" to urban and territorial systems, a model of the demand for activities and services arising from the community hit by a catastrophic event was developed. Such a model, according to the temporal phases of a seismic event –from impact to rehabilitation– and to the localization of the investigated territorial system with respect to the hazard source, was shaped as a "waves" model. These waves describe the rise of different activities or service demands (from medical treatment to accommodation in temporary houses) and their increase in the different time phases following the earthquake.
- The international literature on the concept of resilience. Studies of the early 1970s on the concept of resilience had great relevance to the building up of the systemic approach to the vulnerability of urban and territorial systems. During the last decades, the idea of vulnerability of a (social, territorial, and so on) system as the opposite of its capacity of absorbing perturbations or, in other words, as the "flip-side" of its resilience (Fortune and Peters, 1995), has been more and more diffused in the international literature in the field of risk analysis, pointing out that an ecological, social or territorial system becomes vulnerable when it loses its resilience, namely its capacity of absorbing a change (Folke, Carpenter et al., 2002). Resilience was viewed as indicating the capacity of natural systems to absorb perturbations, and to maintain their functioning and structure, therefore as a function of the "load" that a natural system can absorb before it changes its structure, transforming variables and processes that control its behaviour (Holling, 1973). Later this concept was deeply investigated with particular reference to complex systems, focusing on the capacity of those systems to renew themselves when a stress factor hit the system (Gunderson and Holling, 2002) reaching a new state of equilibrium. Resilience refers to the self-organizing capacity of systems, but

also to their capacity of learning and adapting to external stresses (Folke, Carpenter et al., 2002).

- The World Conference on Disaster Reduction. The resilience of social and territorial systems towards natural disasters represented also a crucial point of debate at the World Conference on Disaster Reduction held in Kobe in January 2005. The final document issued from the Conference recognized "the development and strengthening of institutions, mechanisms and capacities at all levels, in particular at the community level, that can systematically contribute to building resilience to hazards", as one of the strategic goals for risk mitigation. In this Document "resilience" was defined as "the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase this capacity for learning from past disasters for better future protection and to improve risk reduction measures" (UN/ISDR, 2004).

Taking these theoretical inputs as a point of departure, UNINA's approach, which, as mentioned earlier, is specifically grounded on the planners' point of view and aims at guiding spatial planning strategies towards risk mitigation, was developed initially with reference to seismic events, although it exhibits some general features making it easily applicable to other types of hazard analysis. This approach focuses on the vulnerability of urban and territorial systems interpreted as a multidimensional concept, depending on physical vulnerability, essentially related to the typological and structural features of buildings or infrastructures; functional vulnerability, mostly related to the fragilities arising from the relations among the different components of the system (spaces, activities, population, etc.); and organizational vulnerability, pertaining to the fragilities resulting from the legal system and from the capability of the institution in charge of emergency management to face post-event crisis. The main features of the approach are summarized below:

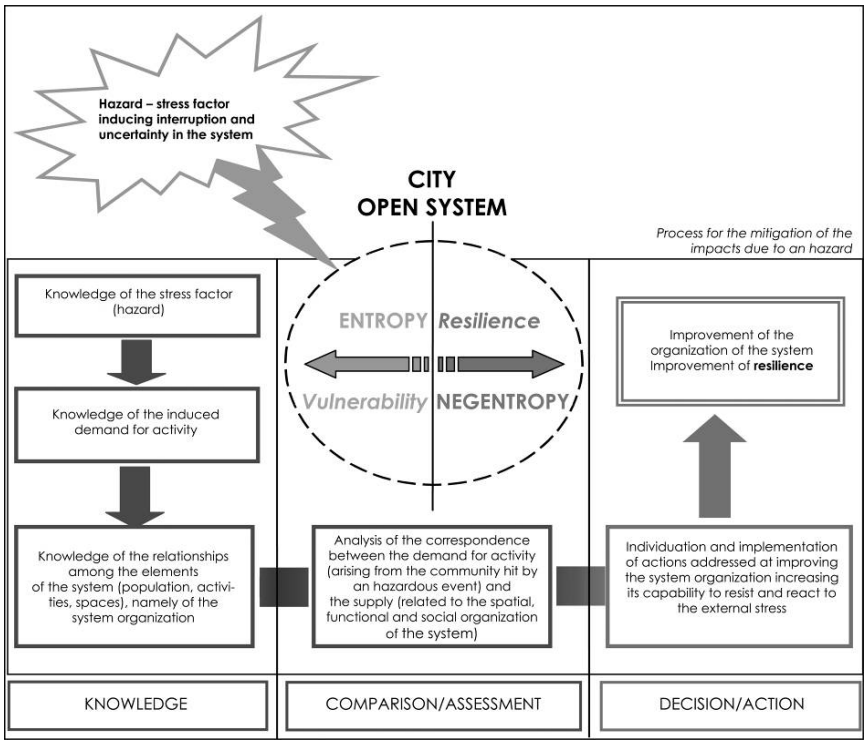
- Functional vulnerability of urban and territorial systems. Attention was mostly paid to functional vulnerability, interpreted by the researchers as a measure of the performance of the urban fabric spatial organization with respect to the demand for activities and services due to a seismic event. The analysis allows to single out urban areas where, according to the features of the urban fabric (e.g. high compactness, very narrow streets, etc.), the system is "structurally" incapable of supplying the demand for activities and services due to a seismic event (moving towards safe places, access of rescue teams, etc.) (Galderisi, 2004). The measurement of functional vulnerability thus defined has been carried out according to the morphological features of urban fabric and to the rules of aggregation of physical elements constituting it (buildings, open spaces, road networks, etc.) (Ceudech, 2004).

- Vulnerability/resilience of urban and territorial systems. The approach has been further developed in subsequent projects, focusing on resilience and its relationship with vulnerability and paying attention mostly to the vulnerability of urban and territorial systems, interpreted as the opposite of their resilience. In other words, hazardous events have been interpreted as events which may induce interruption and uncertainty in the system structure, increasing its entropy. Hence, urban and territorial systems, as open systems, may counter hazardous events, with a variation of opposite sign (negentropy). The latter can be obtained through an increase of the organization of the system, therefore its resilience, through actions targeted to change the relationships

among the elements (fig.1). By looking at the urban and territorial systems as performance systems targeted to supply the population demand for spaces, activities, services, the UNINA team focused on the gap between demand for activity due to an hazardous event and supply from urban and/or territorial systems. Such a gap may be due both to functional, spatial, social features of urban and territorial systems and, and more specifically to the relationships among the different elements of the system itself or, in other words, to its organization. The focus of research was on a specific period of time, that of post-event emergency (Galderisi, 2006).

- The post-event emergency phase. In that phase the gap between the demand for activity due to an hazardous event and the spatial and functional organization of the city may induce a loss of efficiency affecting not only, immediately, the number of victims, but also, in short-medium term, the system capacity of absorbing the change, and of restoring normal functioning. The above approach allows planners, by acting on the vulnerability of urban system, to counter the increase of entropy due to the hazard, avoiding the collapse and the shift towards a different (generally lower) state of equilibrium: in other words, it allows to increase the resilience of urban and territorial systems.

Figure 1: Improving the resilience of urban systems to disasters: phases and actions



On its part POLIMI, suchlike UNINA, started from the consideration that planners and decision makers need practical and usable tools to avoid creating future vulnerability while developing or redeveloping parts of cities and settlements, and to try reducing wherever possible existing, present levels of vulnerability. Another important assumption taken by POLIMI's previous work relates to the notion of chain of failures and losses, leading to the identification of vulnerabilities not only linked to the physical characteristics of the hazard, and therefore aimed at controlling the "impact"

of the event, but, rather, recognise the temporal development of any disastrous event. This implies to address at least two phases, for which vulnerability considerations are relevant:

- impact, in this respect the vulnerability to the physical pressure and stress produced by the extreme event is considered;
- subsequent phases, when territorial systems are asked to withstand a certain level of impairment and losses without collapsing.

In this regard notions like coping capacity and resistance as opposite to vulnerability acquire importance and significance: resistance relates to the physical capacity to avoid losses and damages by overcoming successfully the stress produced by the feared event. Coping capacity instead refers to the ability of hit territorial system to keep functioning and reacting to some level of physical damage. In this regard, the input of a coping capacity assessment is not directly the stress, the pressure provoked by the extreme event, but the level of losses and impairment that systems underwent as a consequence of the pressure at the impact. This is the reason why in many examples of vulnerability assessment (see in particular lifelines) the latter has been divided in two parts: vulnerability assessment to the impact, to the emergency and to the recovery phases.

The perspective according to which the contribution of POLIMI has been developed until now is twofold, one deriving from urban and land use planning, the other from different engineering branches, mainly related to the phenomena at stake and to the need to reinforce and design solutions to withstand expected pressures on structures.

As for the first approach, it is more theoretical and similar to the ones expressed in the report by HUA and UNINA. It may be summarized according to the following table:

Components of the built environment	Physical vulnerability	Type of use of built environment's components	Frequency of use of built environment's components	Density of use of built environment's components	Accessibility factors	Utilities/facilities performance
residential buildings						
industrial facilities						
lifelines						
public facilities						
.....						

In particular, the table shows the approach that has been attempted until now: on the one side (rows), different components of any urban or regional environment have been analysed. Although it is clearly recognised that relationships among the various sectors is vital to understand the functioning of complex settlements and therefore of territorial vulnerability, it must be also kept in mind that without deepening our understanding of the mechanisms at the root of individual components' vulnerability,

there is little hope to be able propose mitigation measures. Despite of a certain level of simplification it is supposed that systemic considerations of relationships among systems, of those factors that constitute the overall, global vulnerability of a complex system, far beyond the sum of individual components vulnerability, are useful to assess priorities, to identify what components/systems are weaker, what components/ systems deserve major attention or are more easily tackled with available means and resources.

The columns instead address aspects that range from physical components (the ones on which engineering expertise can provide most information and assessment capabilities) to wider territorial considerations. The most important aspect to be considered is that the scheme alludes at the need to identify the relationship between the various aspects, therefore between utility performance, accessibility, type, frequency and density of use, with the aim of complementing the physical vulnerability assessment with functional and systemic considerations. An example may clarify the notion. In many disasters, major as well as minor, it emerged clearly how uses of areas and buildings may significantly change physical vulnerability patterns: first floors used as storage place induce also structural changes that may impair the building's capacity to withstand for instance an earthquake.

The second perspective according to which POLIMI has addressed vulnerability started from the identification of individual objects/components of the built environment from a territorial point of view. In this respect the vulnerability assessment is not limited to structural, engineering considerations only, but implies also links to aspects such as accessibility, dependence from utilities, and even organisational factors. A very relevant example of such territorial declination of physical vulnerability assessment relates to the question of how to measure vulnerability parameters to seismic risk at different geographical scales. In this regard, the traditional point shaped, at the building scale approach, which is typical of engineering, has been complemented by other approaches, adopting statistical and sampling techniques, so as to provide results that can be used for different purposes at different scales. In particular:

- In the case of small settlements, where a building by building survey is possible, specific survey and evaluation techniques have been applied. The result is certainly relevant for the local scale, showing the features of different building types that lead to high/medium or low capacity to resist an earthquake. The result is certainly useful to complement for example a transformation or restoration urban plan.
- In the case of medium settlements, or of various small settlements in a province, a valley or any other territorial unit, a sampling technique has been adopted. In this case different types of buildings are identified, also with the contribution of urban planners and historians, in order to identify classes of buildings uniform as far as their fundamental construction features are concerned. Samples from each class are then selected in order to conduct the evaluation that is then extended to the entire class.
- A third level of approximation refers to larger metropolitan areas, when the number of buildings to be assessed grows significantly and beyond the possibility to identify classes and typologies. In this case a statistical approach using "poor data", that is census data has been adopted. Clearly the output of such analysis cannot be used for specific projects and plans. Though it permits identifying priorities and basic differences within the area of interest.

The latter level of approximation has been adopted to assess the vulnerability of the built stock in Italy in general terms. In the latter case the statistical grouping of

census data has been substituted by an expert judgement of the vulnerability of the built stock in each Italian province, based on experts' own knowledge and on basic parameters like the incidence of masonry constructions and average age. Again, the result is relevant in aggregate terms, to identify priorities at a national level, hotspots of vulnerability within the country's built stock.

Finally, another important aspect where planning perspective has enlarged the scope of engineering one, relates to the proposal of experimental methods to assess the vulnerability of built blocks making part of a unique structural unit. Identifying parameters describing such vulnerability is not easy, but very significant for restoration and reconstruction plans in historic centres.

As in the case of UNINA's approach POLIMI's perspectives have been found akin to or inspired by theoretical models and experimental projects elsewhere:

- The Cairns example: Granger et al (1999) presented a rather interesting example of vulnerability assessment applied to a county level in Australia. The starting point is a definition of vulnerability rather similar to the one that has been provided in this contribution. Besides, the core framework of the assessment is also strikingly similar, despite of the fact that the two approaches have been developed completely independently one form the other. In particular the Granger's approach identifies five main areas for settlement's vulnerability assessment, named:
  a. setting
  b. shelter
  c. sustenance
  d. security
  e. society

  The five areas of concern relate respectively to the accessibility of various functions, services, potentially stricken areas (setting), to the built stock vulnerability (shelter), to the performance capacity of lifelines (sustenance), to public health concerns (security) and to the coping capacity of potentially affected communities (society). The Cairns example is relevant in our view not only because of its similarity to the POLIMI one, but also because it conveys a territorial perspective, as territories are defined as complex systems for which all the five areas are relevant individually and in their mutual relationships.

- The example of industrial vulnerability assessment to floods in the Loire Catchment, France: The example provided by the Loire River Basin Authority within the Loire Catchment plan as far as industrial vulnerability to floods is concerned, is of extreme interest, for two main reasons: first because it provides information and first attempts to identify parameters regarding complex "objects" like plants that have been rarely considered until now; second because of the methodology that has been followed. In order to identify vulnerability parameters, the situation of existing plants in the river basin has been confronted to similar ones that underwent damages in the past as a consequence of flooding. Specific and detailed analysis of damage is provided with respect to the latter (Ledoux, 1999).

Summing up, UNINA's and POLIMI's research path led to the development of an approach to the vulnerability of urban and territorial systems strongly addressed to single out spatial planning strategies for the mitigation of the impacts caused by hazards and as much as possible "integrated" within the process of knowledge-decision-action aimed at driving the evolution of urban and territorial systems. Both

approaches present a strong belief to mapping the vulnerability attribute and its spatial variations and ratings. According to POLIMI maps must be considered not only as a representation tool, but also as means to model complex territorial systems. As suggested by Funtowicz and Ravetz (1990, p. 83-84), *«The skill of mapmaker is involved in helping the user avoid the pitfalls of misinterpretation, by design which makes it clear which sorts of information are provided with a stronger claim of certainty, and which sorts are less certain or ignored…. The map emphasizes the totality; the individual elements are seen and grasped in relational terms».* To POLIMI only such considerations lead effectively to the fundamental goal of vulnerability assessment which is the identification of as many differences as possible within the area of interest. In fact vulnerability considerations are useful as far as they permit selection and differentiation in the built environment, opening the floor for a variety of potential mitigation measures.

Obviously, although not ignoring other relevant dimensions of vulnerability, from the "physical" to the "social" one, the attention has been mostly paid to the vulnerability/resilience of the urban and territorial systems on which it is easier to act through the tools of spatial land-use planning. Emphasis has been put on the assessment of the loss of efficiency of those systems in case of hazardous events.

1.2.3 Floods: The Middlessex University analysis

Regarding specifically flood hazards, the Middlesex University team (Flood Hazard Research Centre) remarks that the concept of territoriality, or territorial vulnerability, has not been widely applied to flood hazards, although Hewitt's analysis entitled "Regions of Risk" (1997) refers briefly to floods and points out, that floods are linear or patchy in spatial extent reflecting topography. Oddly, Hewitt's characterization of flood territories highlights the fact that hydrological processes and floods occur within "process units" called catchments which are referred to below. MDX team draws from the international literature a broad variety of approaches that approximate more or less the concept of Territorial Vulnerability to Floods. Those that are quoted here are only the most representative examples which demonstrate the diverse understandings of the notion of flood vulnerability of territories at different scales (from regional to point locations):

- *Physical and agro-ecological conceptual approach to socio-economic flood vulnerability (Brammer, 2000):* An analysis of socio-economic vulnerability of Bangladeshi settlements and infrastructure since 1970 using agro-ecological regions and zones of flood type (e.g. rainfall, river, tidal floods) for the whole country as an organizing framework. Developed in the context of an ongoing critique of the Bangladesh Flood Action Plan (see also Brammer 1992).

- *Economic and social vulnerability to floods in urban developing nation setting (Islam, 2005, 2006):* Analysis of economic flood impacts and related indirect household and health effects, and their propagation at the macro level in urban Bangladesh focusing on 3 urban settlements. The time-frame is the late 1990s, early 2000s. Initially a PhD thesis but subsequently published in Bangladesh, and a contribution by a Bangladeshi to alleviating flooding there.

- *Socio-economic impact, vulnerability and response to floods in a developed nation setting (Tunstall et al. 1991; 2007):* Studies at (a) the sub-catchment level (1990 floods) and (b) the national level of the impacts, vulnerability and response to floods in England and Wales (1990s-2000s) undertaken for (i) the

UK National Rivers Authority to inform flood alleviation policy and (ii) the EC FLOODsite project (2004-2009). Broadly, similar research has been undertaken in Germany but this focuses upon damage impacts of the 2002 floods, recovery of flood affected residents and insurance (Thieken et al, 2005, 2006, 2007; Steinfuhrer and Kuhlicke, 2007) and in Italy (De Marchi et al., 2007).

- *Political ecology of shanty-town community vulnerability to floods (Wisner, 2000)*: An analysis of socio-economic vulnerability development in Alexandra Township shanty-town, near Johannesburg, against the powerful apartheid and violence background of the 1970s-1990s. Wisner is a leading American advocate of social vulnerability analyses and the approach demonstrates his analysis (see also Blaikie et al., 1994).

- *Urban poverty and geography of socio-economic vulnerability to floods (Zoleta-Nantes, 2000)*: An analysis of vulnerability of urban poor residential settlements ("barangays") to flooding in Metro Manila (The Philippines) between 1970s-1990s. Barangays are the basic administrative political unit in municipalities or cities in the Philippines. This has been developed as a geography project at the University of the Philippines. Another example of this conceptual approach, this time focusing upon displacement of poor people by flooding, in the context of Ormoc City (i.e. city scale), the Philippines, is Mahmud, 2000.

- *Political economy approach to socio-economic vulnerability to floods (Winchester, 2000):* An analysis of the spatial and economic marginalization of agriculturalists in the 20th century (since 1907) by landowners and political officials who control access to resources and services in the delta-island settlement of Divi Seema in the Krishna delta, north of Madras, India. A PhD thesis by Winchester who is an Englishman and now a leading figure in operating a charitable foundation in India.

- *Mega-city disasters and vulnerability to floods (Parker, 1999a):* An examination of social and infrastructure vulnerability to floods and other disasters from medieval to present times in London within a mega-city analytical framework. Development of the International Geographical Union Study Group's initiative on Disaster Vulnerability in Megacities during the 1990s, and with the support of United Nations University, Tokyo. Another example of the same conceptual approach focusing upon Seoul, South Korea is Kwi-Gon Kim (1999).

- *Human ecology and vulnerability to floods (Hewitt, 1997):* A vulnerability based approach to reducing risk to disaster including floods employing a broad-brush temporal and spatial context and arguing for the "geographicalness" of risks. Spatial units considered include the city, and "mountain lands". This book is a reaction by a USA academic to the dominant "hazards paradigm" approach which emphasizes damaging events and agents.

- *Health vulnerability to floods (Tapsell et al., 1999, 2003; Tapsell 2000):* Post-flood study revealing the health and related social effects of flooding in two small English towns in the late 1990s. Research sponsored by the UK Environment Agency in order to gather evidence to support spending on flood measures. Precursor studies undertaken in 1980s in Lismore, Australia

(Handmer and Smith, 1983), a small English coastal community (Green et al., 1984), and by Bennett (1970) in a small English city.

- *Risk construction and social vulnerability to floods (De Marchi et al. 2007; Steinfuhrer and Kuhlicke 2007)*: Anthropological, cultural and sociological conceptualizations of risk and social vulnerability focused upon a) four northern Italian villages and one town and b) the Mulde River valley settlements (villages and towns) in south-eastern Germany. Undertaken as part of the EC sponsored FLOODsite research project. Time-frame is past 10 years, including 2002 floods in Germany.

- *Psychological conceptual approach to individual vulnerability (Drobot et al. 2007)*: Recent psychological study of reasons why drivers in two functional urban areas of the USA drive through dangerous floodwaters. The research is aimed at ways of changing driver behaviour in the future (Drobot et al., 2007). A sub-set of this approach is the Cognitive mapping / perceptual / geographical approach to individual vulnerability (Ruin et al. 2007). Ruin et al. studied motorists' perceptions of flood risk and their travel itineraries through a flash flood area of southern France where many motorists have died in flash floods in the recent past. The territorial unit chosen for this study is the Gard Department and its road network. Academic research project undertaken at University of Grenoble, which aims to improve transportation planning and safety.

- *Planning concepts and vulnerability to floods (DEFRA, Welsh Assembly Government and Environment Agency, 2004; DEFRA 2006)*: The catchment is now a principal territorial unit for assessing flood risks (including exposure and vulnerability) for preparing Catchment Flood Management Plans with the aim of developing long-term sustainable policies for flood risk management in England and Wales. A similar approach is being used for shoreline management units, and there are also Coastal Habitat Management Plans and Water Level Management Plans.

- *Multi-dimensional, integrated risk assessment approach to flood vulnerability (Environment Agency 2007, 2008):* The Environment Agency's Thames Estuary 2100 (TE2100) plan will be a major risk assessment for flooding in the Thames estuary and tidal river Thames plain including London. This is the largest flood risk management plan ever produced for England and Wales and is due to be published during 2009 but work on it has been ongoing for several years and numerous risk assessment and planning documents have already been written. Within this currently confidential plan there is a multi-dimensional, multi-disciplinary approach to vulnerability including vulnerability analyses for infrastructure systems, current institutional arrangements and the population at risk.

In the paragraphs 1.2.4.i - 1.2.4.iv some specific methodologies, representative of the above analyzed three major scientific paradigms of vulnerability conceptualization (the technical paradigm, the social constructivism one and the climate change paradigm, see 1.2.1) are being presented with respect to their distinct rationale. Further down, chapter 1.3.1 outlines the input, the results, the successive steps and the overall identity of a wider range of methodologies: 1) the methodologies representing the three major scientific paradigms on vulnerability (as quoted in paragraphs 1.2.4.i to 1.2.4.iv), 2) the group of methodologies that belong to the land-use oriented approach that has been consolidated as "vulnerability of Territorial

Systems" and 3) the group of methodologies on floods (commented and classified by the MDX team). This third group is quoted separately at the end of 1.3.1 due to its particularity of being classified according to ad hoc spatial scales of reference (on the basis of both human and physical geography criteria).

1.2.4 UNDP, ESPON, Munich Re and HUA

1.2.4.i Vulnerability Conceptualization in the context of the "Disaster Risk Index" (UNDP, Bureau for Crisis Prevention and Recovery, 2004)

The Disaster Risk Index (DRI) addressed and measured the risk of death in disaster at national level in three specific cases of hazard types (earthquakes, tropical cyclones and floods) for the period 1980-2000. DRI is a case representative of the technical school of thought on vulnerability although this is not immediately apparent.

For the assessment of DRI indices the countries of the world are indexed for each hazard type according to their degree of physical exposure, of relative vulnerability and degree of risk. DRI is a mortality – calibrated index. Its development has been guided both by the use of a conceptual model involving physical exposure, vulnerability and risk as well as by the availability of global datasets of a suitable quality. Indeed the choice of mortality has been guided by global data availability and it is recognized that as such DRI provides only a partial picture of risk. According to DRI rationale physical exposure is not an indicator of vulnerability but a condition *sine qua non* for disaster risk to exist. Without people exposed to hazardous events, there is no risk to human life. Physical exposure however, is insufficient to explain risk. Countries with similar levels of physical exposure to a given hazard experience have widely different levels of risk. Vulnerability –in the context of DRI- is the concept that explains why with a given level of physical exposure, people are more or less at risk. It measures the number of people killed in a country due to a particular natural hazard with respect to the number of people exposed. In the DRI vulnerability refers to the different variables that make people less able to absorb the impact and recover from a hazard event (coping and adaptive capacity). These may be economic (such as lack of reserves or low asset levels); social (e.g. the absence of social support mechanisms); technical (e.g. poorly constructed housing) and environmental (such as the fragility of ecosystems (UNDP 2004).

Despite the fact that exposure is accounted as a separate and independent factor in the equation of DRI, vulnerability is theoretically considered (an assumption included in the Report) to include variables that may increase the severity, frequency, extension and unpredictability of a hazard. It ensues then that both development activities that influence hazard and those that influence human vulnerability are represented in the DRI as vulnerability. The vulnerability index is also supposed to include those factors that may decrease vulnerability (e.g. urban planning, disaster preparedness and early warning systems). According to DRI rationale vulnerability is hazard specific and there is no possibility for a global multi-hazard indicator of vulnerability. While the DRI project evaluates vulnerability indices at national level the ESPON Hazards project attempts such an evaluation at regional level (NUTS III) across the EU territory.

1.2.4.ii The Concept of Territorial vulnerability in the ESPON Hazards Project (2005)

The ESPON Hazards Project takes vulnerability as the degree of fragility of a person, group, community or an area; as a set of conditions and processes resulting from physical, social, economic, environmental factors that increase the susceptibility of a community to the impact of hazards. The term territorial vulnerability is not used as such; the terms used instead are regional vulnerability and vulnerability of urban centres. The ESPON Hazards Project acknowledges damage potential and coping capacity as the two main components of vulnerability: Damage Potential + Coping Capacity = Regional Vulnerability. At the same time the project recognizes three dimensions (or locus, or carriers) of regional vulnerability: economic[1], social[2] and ecological[3]. Neither systemic relations between the above dimensions nor systemic vulnerability have been taken into account though it is acknowledged that *"large urban centres are especially vulnerable because the destruction of important systems of communications and infrastructure is costly and can have vast consequences on the economic stability even on the global scale".* In a sense systemic vulnerability is considered only in the context of the economic dimension of vulnerability.

The ESPON Project follows Cutter's notion of "Vulnerability of place" defined as a combination of hazard exposure and social response within a specific geographic area. This means that exposure is considered as an internal (inherent) element of geographical vulnerability. Vulnerability in ESPON Project is "place specific" (but not hazard-specific) and it takes into account the damage potential (including human occupation, infrastructure and natural areas) and coping capacity of regions. The hazards-of-place model of vulnerability, on which the ESPON Project is based, has an explicit focus on locality. As figure 2 indicates biophysical and social vulnerability together form the overall "Place Vulnerability". The hazard potential is filtered through the geographic context (site and situation, proximity) and the social fabric of community (socio-economic indicators, risk perception, ability to respond) and is either moderated or exacerbated by them. In the view of ESPON project vulnerability functions either as intensifier or a factor vitiating the hazard potential.

[1] This is about economic damage potential, understood as anything concrete that affects the economy of a region and can be damaged by a hazard.
[2] It represents the vulnerability of people and the emphasis is on coping capacity.
[3] This is about ecosystems' or environmental vulnerability or fragility.

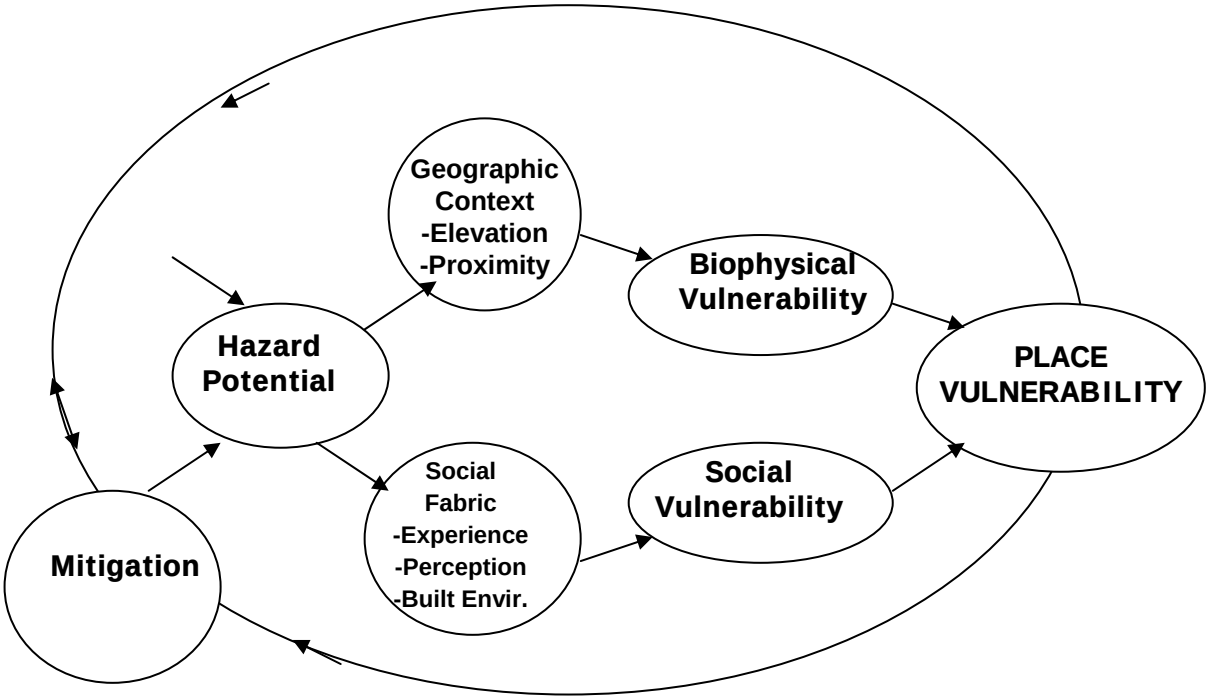


Figure 2: The Hazards-of-Place model of Vulnerability
(Source: Cutter et al, 2003, cited in Kumpulainen, 2006)

1.2.4.iii Physical Vulnerability at Mega-city Scale: The Munich Re Approach

In general terms this approach calculates risks associated with various hazards for mega-cities around the world. The method concerns physical vulnerability of city structures and in this sense it pertains to the first vulnerability paradigm which is characteristic of the technical literature on vulnerability. However, compared to other methodologies of the technical school it presents a particularity, in that it is paradoxically both hazard-dependent and hazard-independent.

Indeed, calculation of vulnerability by the Munich Re method involves the combination of three parameters, one which is hazard-dependent while the other two are hazard-independent (Villagrán de León 2006). The resulting indicator makes use of information on the current status of the city under examination in terms of infrastructure and population and is not based on historical outcomes of previous disasters. The vulnerability indicator does not reflect either the root causes of vulnerability or possible interdependencies and interactions between structural vulnerability, socio-economic, organizational, institutional etc. The composite vulnerability indicator is expressed as a single one encompassing all considered hazards. Besides, the indicator does not capture how vulnerability depends on the magnitude of one or more hazards; it assigns one single value for each city regardless of hazard or its magnitude.

1.2.4.iv Seismic Vulnerability of Micro-territories: The HUA Approach

(Small Manufacturing Firms in Western Athens after the Earthquake of September 9/1999, HUA research project 2003 and Sapountzaki 2005)

Broadly speaking the approach is indicative of the second paradigm focusing on the socio-economic aspects of vulnerability and its socio-economic components (i.e. resistance and resilience); also on the social construction of vulnerability and exposure too.

The approach does not refer directly to territorial vulnerability as such. It is rather about the relationships between vulnerability of macro socio-spatial structures and that of micro-structures. Besides it searches interconnections between physical, socio-economic and territorial vulnerability. The method achieves some relevant findings by examining post-earthquake responses of a specific micro-structure –the Small Manufacturing Firm- in its struggle to survive and recover after the disaster event of September 9/1999 in the specific urban context of Western Athens. Institutional vulnerability has been also taken into account by the approach. This is because not only private recovery practices but state reactions to these practices too had a constant vulnerability redistribution impact. Indeed a continuous ping pong of vulnerability occurs between micro-, medium- and macro-entities during recovery periods. The methodology utilized the micro-structure of SMF as it facilitated (with its multiple presence and networking within the urban fabric of Western Athens) the analysis of transference mechanisms and interconnections between vulnerabilities of micro- medium- and mega urban structures. SMF was actually considered as a micro-territorial unit, a sub-system of the wider urban system, or even better a discrete social domain to use the term introduced by Hilhorst (2004). These assumptions are justifiable by the following facts:

- ✓ The constituent elements of SMFs (i.e. production activity, labour force, technology, immovable capital, etc) relate with each other in functional and partly predictable ways. Besides an SMF is an open adaptive or soft system as it interacts with other SMFs and other types of micro-, medium- and mega-structures too (e.g. consumers, private financing organizations, trade unions, universities, research centres, state agencies).
- ✓ An SMF is a “social domain” because it is a locus of certain rules, norms and values implying a degree of social commitment (Long 2001); because it includes actors who belong simultaneously to other systems; because it has the ability to integrate and rework knowledge derived from other and different systems; also because it allows change from within and the softness of its boundaries since it permits movement and exchange of people, resources and ideas with other domains.
- ✓ An SMF is identifiable in physical and spatial terms by means of its movable and immovable capital; besides its operation is systemically dependent on regular operation of other physical networks and subsystems such as lifelines.

The data used for the study covered a long period and the major part of the disaster cycle that followed the seismic event of September 9, 1999 which had hit Western Athens. In particular the data and information utilized by the study concerned different phases of the recovery cycle of SMFs:

(a) First stage recordings and statistical data on building damage and other losses were available at the Greek Ministries of Internal Affairs, Public Administration and Decentralization on the one hand and the Environment,

Spatial Planning and Public Works on the other (one and three months after the event respectively).

(b) Second stage data and a relevant database for 226 firms, marked "green", "yellow" and "red" according to the degree of building damage, was created by a research team (HUA 2003) on the basis of information available in the records of the Ministry for the Environment, Spatial Planning and Public Works (MEPPW) (three years after the event). This information was completed by primary information obtained via a questionnaire submitted to a representative sample of 50 SMFs for the purpose of collecting detailed information in relation to the identity of hit firms, material and immaterial losses and the adopted recovery process.

Having reviewed the conceptual approaches to territorial vulnerability and the parallel terms (geographical, urban, regional, area vulnerability) we can now proceed to specific examples and their actual results as regards to qualitative and quantitative measures of territorial vulnerability.

1.3 Examples of Methodologies Assessing Territorial Vulnerability

1.3.1 Content and Character of the Methodologies

1.3.1.i Regional level

Vulnerability Assessment in the context of the "Disaster Risk Index"
(UNDP, Bureau for Crisis Prevention and Recovery, 2004)

In the case of DRI risk is a function of hazard occurrence probability, the population at risk and vulnerability. In particular, the equation conveying the conceptualized relationship between risk and vulnerability is the following:

$R = H * Pop * Vul$

Where R is the risk (number of people killed)
H is the hazard, depending on the frequency and strength of a given hazard
Pop is the population living in a given exposed area
Vul is the vulnerability and depends on the socio-political-economical context of this population.

The product of hazard multiplied by the population is considered to reflect physical exposure and the above equation turns into :

$R = PhExp * Vul$

Where PhExp is the physical exposure, i.e. the frequency and severity of a hazard multiplied by exposed population

For the calculation of physical exposure of each country to each of the hazard types under examination (earthquakes, tropical cyclones, floods), the area exposed to respective events was identified and the population living there was counted. The result is the average number of people exposed to a hazard event in a given year. Geographical information systems were used for mapping physical exposure to each

hazard. Physical exposure varies both according to the number of people as well as to the frequency of hazard events. In the DRI physical exposure is expressed both in absolute and relative terms (i.e. the number exposed per million people).

As to the calculation of *Relative Vulnerability* the DRI assumes that people are more or less vulnerable to a given hazard depending on a range of social, economic, cultural, political and physical variables. DRI has used the number of people killed by each hazard type in each country as a proxy for manifest risk. The assumption is that the occurrence of past disasters manifests by definition, the existence of conditions of physical exposure and vulnerability (UNDP 2004). Besides DRI considered as manifested Relative Vulnerability –of a country to a given hazard- the quotient of the number of killed people by the number of those exposed.

Consequently the manifest risk was examined against a bundle of social, economic and environmental indicators through a statistical analysis using a multiple logarithmic regression model. A total of 26 variables selected through expert opinions were available as global datasets and analyzed for each hazard type; it was then possible to pick up those vulnerability indicators that were most associated with risk for each hazard type (UNDP 2004). The vulnerability indicators that were found relevant to flood, earthquake and cyclone hazards are presented in the following Table 1.

The statistical analysis was based on two major hypotheses. First, that risk can be understood in terms of the number of victims of past disaster events. Secondly, that the equation of risk follows a multiplicative model as in the following equation (UNDP 2004):

$$K = C * PhExp^{a} * V_1^{a1} * V_2^{a2} * \ldots\ldots * V_p^{ap}$$

Where

- K is the number of persons killed by a certain type of hazard
- C is the multiplicative constant
- PhExp is the physical exposure, i.e. population living in exposed areas multiplied by the frequency of occurrence of the hazard
- V_i are the socio-economic parameters
- a_i is the exponent of V_i which can be negative (for ratio)

By using logarithmic properties the equation was reformulated as follows:

$$\ln(K) = \ln(C) + a\ln(PhExp) + a_1\ln(V_1) + a_2\ln(V_2) + \ldots. + a_p\ln(V_p)$$

This equation creates a linear relationship between logarithmic sets of values. This allowed significant socio-economic parameters V_i and exponents a_i to be determined using linear regression.

Table 1: Critical Vulnerability Indicators for Earthquake, Flood and Cyclone Hazards

CATEGORIES OF VULNERABILITY	INDICATORS
ECONOMIC	Gross Domestic Product per inhabitant at Purchasing Power Parities
	Total Debt Service (% of the exports of goods and services)
	Inflation, food prices (annual %)
	Unemployment, total (% of the exports of goods and services)
TYPE OF ECONOMIC ACTIVITIES	Arable land (in thousand hectares)
	% of arable land and permanent crops
	% of urban population
DEPENDENCY & QUALITY OF THE ENVIRONMENT	Forests and woodland (in % of land area)
	Human induced soil-degradation
DEMOGRAPHY	Population Growth
	Urban Growth
	Population Density
	Age Dependency Ratio
HEALTH AND SANITATION	Number of physicians (per 1.000 inhabitants)
	Number of Hospital Beds
	Life Expectancy at Birth for both sexes
EARLY WARNING CAPACITY	Number of Radios (per 1.#000 inhabitants)
EDUCATION	Illiteracy Rate
DEVELOPMENT	Human Development Index (HDI)

Source : UNDP/UNEP

Since evaluation of DRI referred to the time period 1980-2000 the socio-economic variables that would be tested had to be converted into 21-year averages and only then transformed into a logarithmic value. For those expressed as a percentage a transformation was applied in order that all variables would range between $-\infty$ and $+\infty$ (see equation below). For others no logarithmic transformation was needed (UNDP 2004).

Transformation for variables ranging between 0 and 1

$V_i' = V_i / (1 - V_i)$

Where V_i' is the transformed variable (ranging from $-\infty$ to $+\infty$)
V_i is the socio-economic variable (ranging from 0 to 1)

The model of DRI allowed the identification of parameters leading to higher and lower risk. However, it should not be used as a predictive model. Small differences in the logarithmic scale can induce large ones in the modeled number of deaths (UNDP 2004). The respective report of UNDP ("Reducing Disaster Risk – A Challenge for Development") speaks for high and relevant results. Finally, mapping the input and output parameters, factors and synthetic indicators (e.g. numbers of killed, killed per million inhabitants, killed per population exposed) has been an integral part of the whole DRI procedure.

Assessing Regional Vulnerability in the ESPON Hazards Project (2005)
(Kumpulainen 2006)

As it has already been mentioned the methodology of the ESPON Hazards Project has been based on the integrative model for the "Vulnerability of Places" proposed by Cutter (1996). The area unit used for the application of the methodology has been the so-called NUTS 3 region and the results are shown on maps of the EU 27+2. The indicators used have been chosen in order to cover *damage potential* and *coping capacity*, as well as the range of all three vulnerability dimensions. The Coping Capacity indicators measure the ability of a region to prepare for, or respond to, a hazard. They measure either human properties or the existence of appropriate infrastructure.

More specifically the methodology considers 6 indicators for the "damage potential" of vulnerability and 11 indicators for "coping capacity". Of the 6 indicators referring to damage potential two are economic, another two have both economic and social content and the remaining two are ecological. In detail the damage potential indicators are the following:

- ✓ Regional GDP/capita
- ✓ Population density
- ✓ Number of tourists or number of hotel beds (this is considered as a coping capacity indicator too)
- ✓ Number and area size of significant natural areas
- ✓ Number and area size of fragmented natural areas
- ✓ Culturally significant sites (e.g. sites included in the UNESCO world heritage list)

The coping capacity indicators are:

- ✓ National GDP/capita
- ✓ Education rate
- ✓ Dependency ratio
- ✓ Risk perception
- ✓ Institutional preparedness
- ✓ Medical infrastructure
- ✓ Technical infrastructure
- ✓ Alarm systems
- ✓ Share of budget spent on civil defense
- ✓ Share of budget spent on research and development

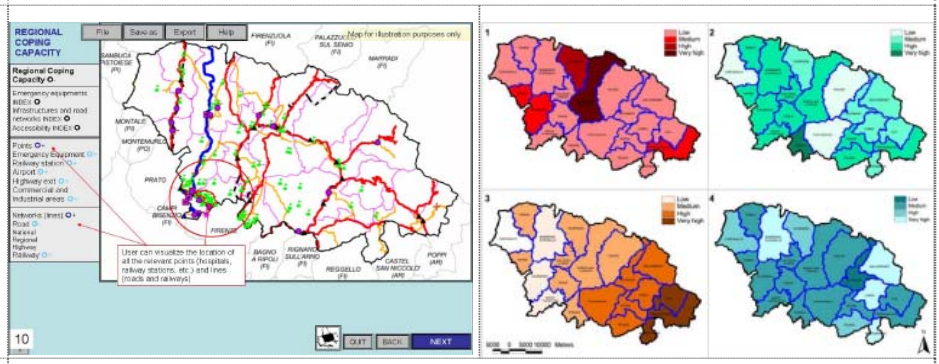
When it came to actual application however, some serious problems emerged; several indicators could not be used or evaluated due to a lack of data or difficulties in quantification (for instance institutional preparedness and risk perception proved impossible to measure). Due to these difficulties only four indicators were finally used (regional GDP/capita, population density and the extent of fragmented natural areas as damage potential indicators and national GDP/capita as coping capacity indicator). The integrated then regional vulnerability index (and consequently map) results as the aggregate of the homogenized indicators where regional GDP contributes with a weight of 30%, population density with 30%, fragmented natural areas with 10% and national GDP with 30%.

Mapping Regional Vulnerability in the context of ARMONIA (Framework Programme "Applied multi Risk Mapping of Natural Hazards for Impact Assessment"), Deliverable 5.1, EU STREP VI 2004-2007
(Galderisi and Menoni, 2007)

This methodology is representative of the strand dealing with vulnerability of territorial systems for the purpose of supporting spatial planning risk mitigation policies. The following Table 2 summarizes the basic features of the methodology.

Table 2: ARMONIA methodology for Regional Vulnerability Mapping with reference to Multi-Hazard conditions (Galderisi and Menoni, 2007)

Type of hazard:	Multi risk (earthquake, landslide, flood, forest fire, volcanic risk)
Scale:	Regional
Territorial vulnerability approach:	The multi-dimensional concept of vulnerability expresses the capacity of a system to face a hazardous event, with respect to direct damages, such as physical damages and consequent human suffering, and indirect damages due to incapacity of a system to face the event (e.g. inadequacy of road network which impedes rescue team access). The methodology takes into account: physical vulnerability of building stock; vulnerability of population; coping capacity, i.e. the availability of resources (quantity and hierarchical level of emergency equipment; infrastructure and roads; accessibility from the external territory) enabling each municipality to face a hazardous event.
Aim:	The aim of the ARMONIA project is to provide the EU Commission with a harmonized methodology for producing integrated risk maps to achieve more effective spatial planning procedures in areas prone to natural hazards. The assessment is part of a Decision Support System for achieving land-use planning processes fully informed both about the hazard, exposure and vulnerability of different land-uses and the options available to mitigate the risks.
General description of the methodology:	For each hazard, exposure and vulnerability of people and building stock are considered. The coping capacity is the same for all hazards. The coping capacity indicators are aimed at evaluating the services (in terms of strategic equipments such as hospitals, fire brigades, etc. and in terms of road networks) of different regional areas (municipalities) for facing the emergency phase following a hazardous event and the accessibility from external areas to each municipality. The lack of aggregate indexes of vulnerability is due to the deliberate choice of providing land-use planners with disaggregated information as supporting tool for the definition of mitigation measures.
Assessment procedure:	Coping capacity indicators referred to strategic facilities, infrastructures and road network accessibility, are applied with respect to municipalities and are defined as the product of the density of the considered element (e.g. the number of emergency facilities in the municipal area) by a weight coefficient

	from 1 to 3 representing its hierarchical level. The values obtained are ranked into 4 classes with a "natural breaks" statistical method. Aggregated indexes are not provided.
Main indicators of territorial vulnerability:	The emergency equipment index for each municipality (Iem=(ΣiWi*Ei)/Sa) is related to the number of emergency equipments (Ei) and to their hierarchical level (Wi is a weight coefficient from 1 to 3 for local, urban, regional level). The Infrastructures and road networks equipment index (If=Inf+Ip) is the sum of an index (Inf=(ΣiWi*INFi)/Sa) related to the surface of infrastructures (INFi) and their hierarchical level (Wi is a weight coefficient from 1 to 3 for local, urban, regional level) and an index (Ip=(i Wj*Rj) /Sa) related to the length of roads (Rj) and their hierarchical level (Wi is a weight coefficient from 1 to 3 for highway, national, regional roads). The accessibility index (Ia=(Σi Wi*Ai)/Sa) takes into account the number (Ai) and the hierarchical level (Wi is a weight coefficient from 1 to 3) of the 3 classes of main access road typology (highway, national, provincial). All the indexes have been referred to the surface of the municipality (Sa) and ranked into 4 classes.
Input data:	The assessment is implemented within a GIS environment. Data have been collected and processed with regard to census units and aggregated with respect to each land-use within a municipality. Data referred to the coping capacity have been collected and processed directly at municipality level. Although census data have been used for exposure and vulnerability, coping capacity data have been collected from cartographical material and thematic maps.
Example views:	

Assessing and Mapping Vulnerability of Lifelines to Earthquakes: An Italian Research Work developed within the POLIMI Activity Programme 2001-2003

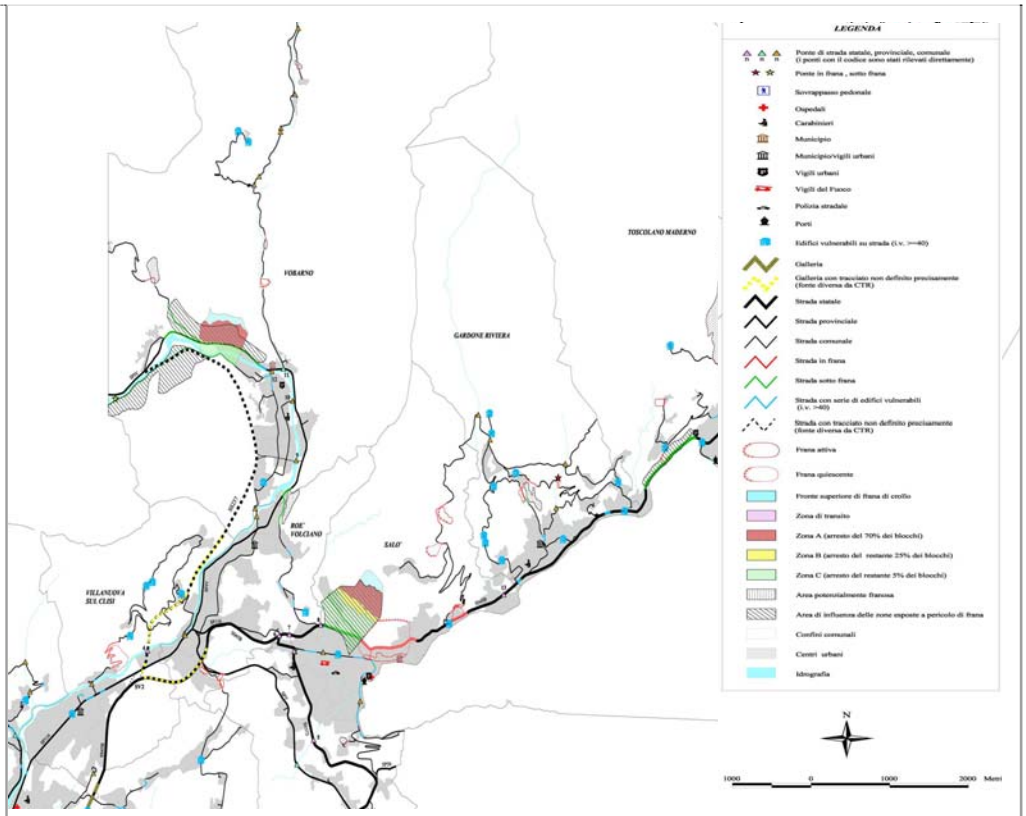
(Menoni et al., 2007)

The present case refers to lifelines, where a territorial approach has been clearly adopted in order to address the vulnerability of such systems that clearly goes beyond the sum of the vulnerability of individual elements, be them joints, plants, or segments. The notion of systemic vulnerability, meaning interdependence between lifelines and between the latter and other urban and regional systems is central to the developed methodology (see Menoni et al. 2007).

Table 3: Lifelines vulnerability assessment to earthquakes

Type of hazard	Seismic
Scale	Large areas
Territorial vulnerability approach	Vulnerability is interpreted as a complex concept comprising physical, systemic, functional and organisational aspects, addressing the main issue of how prone are lifelines to stop functioning as a consequence of physical damage and service interruption after an earthquake
Aim	To provide a methodology for assessing the vulnerability of lifelines to earthquakes, considering both the emergency and the recovery/reconstruction phases.
General description of the methodology	The methodology is based on an assessment matrix comprising physical, systemic and organisational vulnerabilities related to lifelines and to urban and regional systems dependence on lifelines. The result of the assessment matrix can be represented in tables and in maps
Assessment procedure	The method can be run either at a municipal level or evaluating the individual lifelines segments whenever data are available for a more detailed survey and assessment
Main indicators of territorial vulnerability	Systemic and organisational parameters are territorial in their very nature, as they refer to systems' relations and to the consequences public administrations' decisions have on lifelines functioning. Indicators such as redundancy versus uniqueness, accessibility, siting of lifelines with respect to each other are some of the key parameters that have been proposed and assessed in the application to the Brescia province (Lombardia).
Input data	The assessment is implemented in a GIS environment composed of point shaped elements, corresponding to plants, and linear elements, corresponding to segments of the network. The input data are obtained by cartography, surveys, structured interviews with responsible personnel of lifelines managing companies.

Example views



1.3.1.ii Functional Urban Area (FUA) or Metropolitan level;

Physical Vulnerability at Mega-city Scale: The Munich Re Approach
(Munich Re 2003)

As the method attempts to evaluate the fragility of the physical structure of Mega-cities the determinant parameters used represent issues that express or influence the structural resistance of the urban fabric:

- Structural vulnerability: related to the building classes most predominant in the city;
- Standard of preparedness / safeguards: associated with the existence of building regulations, town and country planning with respect to hazards; and
- General quality of construction and building density.

Structural vulnerability, preparedness and quality of construction were assessed using a four degree scale (very good, good, average and below average). Building density was represented through population density and was normalized in a range from 0 to 4 units. The three components were assigned equal weights and combined to generate a single indicator for each city. Figure 3 displays vulnerability -in arbitrary units- of several mega-cities. The list is headed by Karachi, Jakarta, Dhaka, Manila and Calcutta. The cities with the lowest vulnerabilities are Washington-Baltimore, Santiago and Osaka-Kobe-Kyoto. What is interesting about the findings of the approach is that vulnerability of cities does not seem to correlate with their population size (Villagrán de León, 2006).

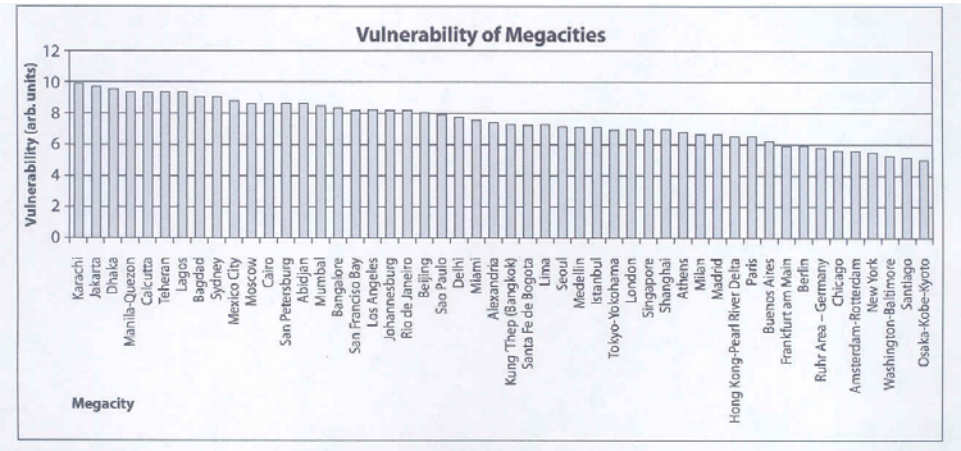


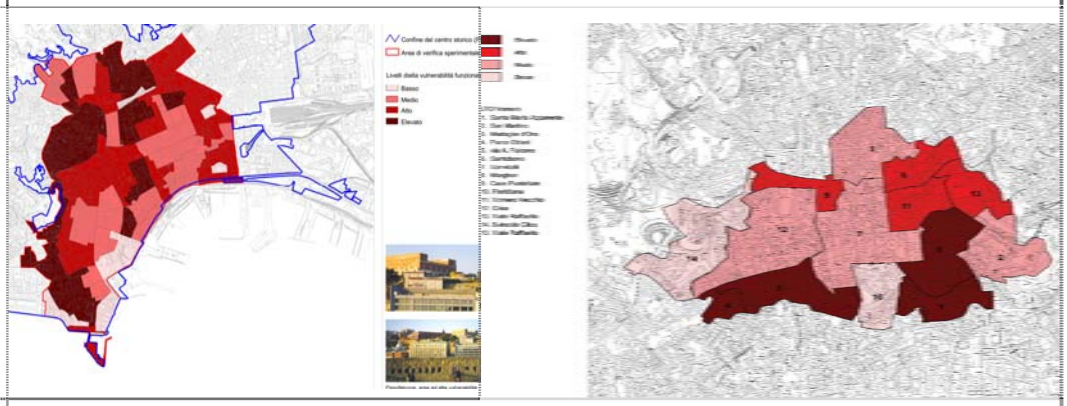
Figure 3: Vulnerability of several Megacities according to the Munich Re approach
Source: Villagrán de León (2006)

City-Metropolitan Vulnerability according to the Italian CIPE-MURST Research Project: "The seismic risk protection: vulnerability, analysis and requalification of the physical and built environment with innovative techniques". (UNINA / Di.Pi.S.T. 2003; Galderisi, 2004)

This methodology too is representative of the Italian strand dealing with vulnerability of territorial systems for the purpose of supporting spatial planning risk mitigation policies. The following Table 3 summarizes the basic features of the methodology.

Table 4: CIPE-MURST methodology for City-Metropolitan level Vulnerability Mapping with reference to Earthquakes (UNINA / Di.Pi.S.T. 2003, Galderisi 2004)

Type of hazard	Earthquake
Scale	City – Metropolitan urban areas
Territorial vulnerability. approach	The urban system vulnerability is due to many factors, such as physical, functional, social, enabling the city to cope with a seismic event. The focus of the research work is on functional vulnerability, interpreted as tendency of the city towards functional crisis due to the lack of correspondence between the high demand for activities and services from the population hit by the earthquake and the spatial organization of urban fabric.
Aim:	To provide an easy-to-apply seismic risk assessment procedure for large urban systems in order to define priority intervention areas.
General description	First, spatial units, representing the cells of a spatial orthogonal grid for the assessment, have been singled out on the basis of site morphology, census unit borders, and on functional and physical features of the settlement being analyzed. In the spatial units so defined, the exposure and functional vulnerability assessment has been carried out. The values obtained from the exposure and functional vulnerability indicators have been ranked into 4 classes (Low, Medium, High, Very High) through the natural breaks method.

Assessment procedure	The level of functional vulnerability is expressed by ranking into four levels (Low, Medium, High, Very High) the Ivf indicator. The latter is obtained as the product of two indicators representing the regularity of the form of the urban fabric (Ivm) and the type of spatial concentration of physical town planning elements characterizing the urban fabric (Iva). The first indicator, which varies from 1 to 2, is defined on the basis of a typological classification of urban fabrics according to their regularity of form. The second one is the sum of six basic indicators, normalized between 0 and 1, representing building density and other elements of the urban fabric, such as public and private open spaces, roads, buildings, etc.
Main indicators of territorial vulnerability	The basic indicators (I1 to I6) that define the Iva indicator, are the following: • the relation between the surface occupied by buildings (Sc) and the area of the spatial unit under consideration $(Sc/St)^{-2}$; • the ratio between private open spaces (Sa) and the surface occupied by buildings $[1 - (Sa/Sc)]^2$; • the ratio between public open spaces (Sp) and the area of the spatial unit under consideration $[1-(Sp/St)]^2$; • the ratio between road surface (Sm) and the area of the spatial unit under consideration $[1 - (Sm/St)]^2$; • the building density $(Dt/10)^{-2}$; • the average distance expressed in meters (Lm) between the fronts of the buildings and street line along the road network (if Lm < 5 m then I6 = 1; if Lm > 15 m then I6 = 0, if 5m < Lm < 15 m then I6 = (15-Lm)/10).
Input data	The vulnerability assessment is implemented through a GIS, processing data obtained from cartographical material; only building heights have been reported from in situ surveys.
Example views:	

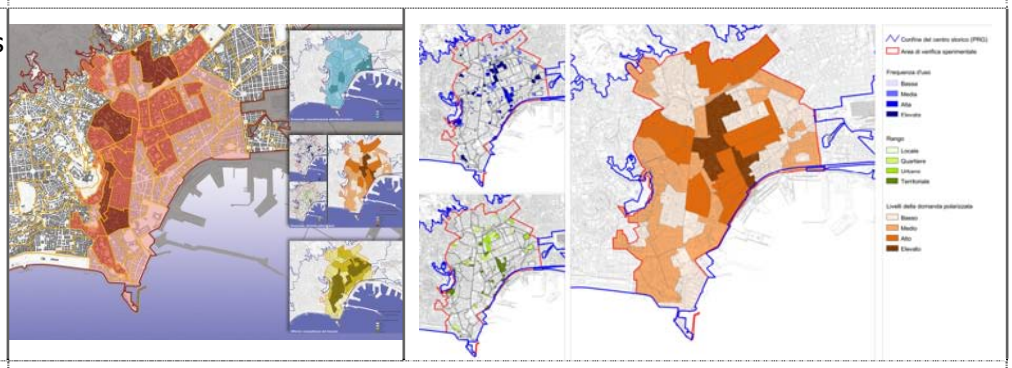
Mapping Vulnerability of Historical City-Centres: An Italian Research Project

(UNINA / Di.Pi.S.T. 2004; Menoni, 2004; Ceudech, 2007)

The methodology is again characteristic of the Italian strand that focuses on the concept of vulnerability of "territorial systems" for the purpose of optimizing risk mitigation and particularly seismic protection policies through spatial planning. The following Table 4 summarizes the basic features of the methodology.

Table 5: Systemic Vulnerability in Italian Historical City-Centres
(The methodology of the Italian research project "The Safeguard of the Historical, Landscape and Cultural Heritage of the Italian Seismic Risk Areas" 2002-2004)

Type of hazard	Earthquake
Scale:	City – Metropolitan urban areas with relevant historical centre
Territorial vulnerability approach	Vulnerability is a multi-dimensional concept, interpreted as propensity of the city to be damaged by a seismic event. The systemic vulnerability concept highlights the incapacity of the urban system to cope with the seismic event and it is referred to the relationships among urban sub-systems, to the functional interdependency of urban areas, to the incapacity of the city to supply the population hit by the earthquake with adequate services and equipments.
Aim	To single out priority areas characterized by high levels of systemic vulnerability in historical centres of large urban systems
General description of the methodology	The systemic vulnerability assessment is based on the definition of territorial units (HTU) which are homogeneous in terms of age, types and features of urban fabrics and demarcated with reference to census unit boundaries. The demand assessment has been related to the number of users both of residential and tertiary activity and of urban activities. The supply depends on the functional and spatial features of territorial units, which can be measured through indexes referred to the compactness of the urban fabric, the permeability of the road network, the accessibility for the rescue teams. The comparison between demand and supply defines "critical" areas.
Assessment procedure	The demand assessment is referred both to spatially distributed activities (PId) and to polarized ones (PIp). For what concerns the former, 2 indicators have been selected (population density and concentration of tertiary activities). The values obtained have been ranked into 3 classes (high, medium, low) and then scores varying from 3 to 1 have been assigned to each class. The ranking into 3 classes of the sum of these scores defines the level of demand arising from spatially distributed activities. For what concerns polarized activities, the hierarchical role and frequency of use have been considered. The sum of all the scores, normalized and then ranked into 3 classes, assigned to each activity which is included in the HTU under consideration defines the level of demand generated by polarized activities (Pp). The sum of PId and PIp, obtained by assigning scores to the demand levels (3 for High, 2 for Medium and 1 for Low), ranked into 3 classes, defines the demand level of each HTU (1-2 Low, 3 Medium; 4-6 High). For what concerns supply assessment, indicators referred to the amount of infrastructures which can be found in each HTU, the compactness of urban fabric, the permeability of secondary road network and the accessibility to rescue teams have been taken into account. Each indicator has been normalized and ranked into 3 classes (low, medium, high). The supply level of HTUs is defined by ranking into 3 classes the ratio between the sum of the scores obtained for each indicator and the maximum possible supply score. The systemic vulnerability level is obtained through the difference between the demand and supply levels of each HTU obtained by assigning a score variable from 1 (low) to 3 (high).

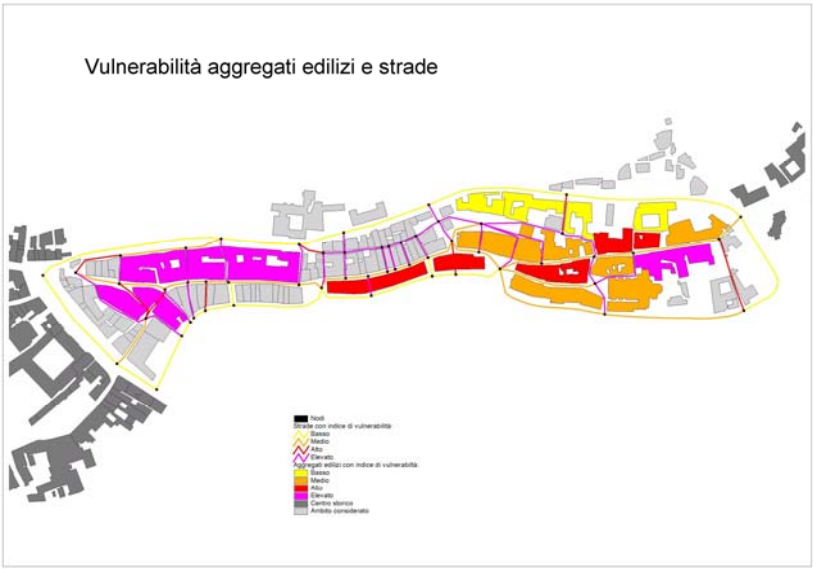
Main indicators of territorial vulnerability	For what concerns the demand of spatially distributed activities, the ratio between population density of the HTU and the average population density of the analyzed area and the tertiary density index, defined as ratio between number of tertiary activities and total amount of tertiary activities of the study area per 1000, have been considered. For what concerns the polarized activities, to each activity a score, variable from 1 to 3, related to its hierarchical role is assigned (territorial, urban and neighbourhood level). The frequency of use is defined as the amount per month of operating hours for each activity (low frequency for 26 hours/month, high frequency for over 240 hours/month). For what concerns the supply, the infrastructure index (Sv\St) expresses the ratio between road surface (Sv) and the area of the HTU (St); the index expressing compactness of the urban fabric is defined as the sum of 3 indexes: building density (Dt), ratio between the area covered by buildings and the HTU surface (Sc\St), ratio between open spaces and surface of the HTU (1 - Sa\St); the permeability of secondary road network is obtained through the sum of 3 indexes referred to the average length of the secondary roads (Lm), average gradient of secondary roads (Pm), average of the percentage of the length of curved roads over the total length of secondary roads. The accessibility index takes into account the gravitational areas of each emergency activity and the redundancy due to the presence of more facilities in the area.
Input data	The systemic vulnerability assessment is implemented through a GIS. Inputs used were processed census data, data obtained from cartographical sources and some data obtained from *in situ* surveys such as building height.
Example views	

Assessing Vulnerability to Earthquakes of Historical City-Centres: An Italian Research Project

(The methodology within the Italian research Activity Programme of the POLIMI 2002-2004)

The present case relates to the vulnerability assessment of a small historic centre; in this case the key notion is the identification of specific characteristics of historic towns that make them unique and therefore vulnerable also to the potential loss of cultural identity.

Table 6: Assessment of historic centres vulnerability to earthquakes

Type of hazard	Seismic
Scale	Local scale
Territorial vulnerability approach	Vulnerability is interpreted as a complex concept comprising physical, systemic, functional aspects, related to the influence of buildings vulnerability on city functions and to the vulnerable features that are specific to historic centres (structural blocks, relationship between built and open space, accessibility)
Aim	To provide a methodology for assessing the vulnerability of small historic centres
Description of the methodology	The methodology is based on a number of consequent vulnerability assessment maps and tables, addressing the vulnerability of buildings, structural blocks, roads, electric lines, open spaces.
Assessment procedure	Each aspect is addressed separately and then combined in the damage scenario assessment
Main indicators of territorial vulnerability	Indicators of vulnerability include the vulnerability of blocks considered as a unique structure as oppose to the vulnerability of individual buildings, the vulnerability of decorative elements, that, though not fundamental for resistance purposes are important for keeping the historic centre ambience.
Input data	The assessment is implemented in a GIS environment composed of point shaped elements, corresponding to buildings, open spaces and linear elements, corresponding to segments of the road and electric network. The input data are obtained by cartography, in situ surveys.
Example views	

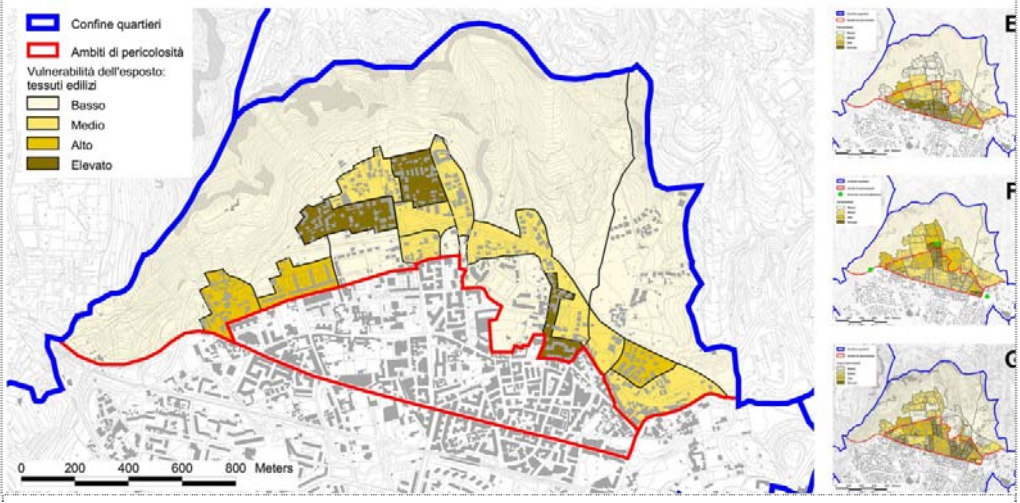
1.3.1.iii Neighbourhood level;

Mapping Neighbourhood Vulnerability and Risk to Mud Flows: An Italian Research Work developed within the UNINA-DIPIST Activity Programme 2006-2008
(UNINA / Di.Pi.S.T. 2008; Galderisi and Ceudech, 2008)

The methodology is again characteristic of the Italian strand that focuses on the concept of vulnerability of "territorial systems" for the purpose of optimizing risk mitigation (in this case protection against mud flows) through spatial planning. The following Table 5 summarizes the basic features of the methodology.

Table 7: Neighbourhood Vulnerability to mud flows
(The methodology within the Italian research Activity Programme of the UNINA / DiPiST 2006-2008)

Type of hazard	Hydro geological – Rapid mud flows
Scale	Neighbourhood - Urban areas prone to mud flows
Territorial vulnerability approach	Vulnerability is interpreted as result both of the physical features of individual buildings and of specific features of urban fabric such as, for example, accessibility from the main road network or the permeability of the local road network, which may affect the possible exodus of population from the affected area and the access of emergency rescue teams.
Aim	To provide a method for assessing the risk related to rapid mud flows aimed at supporting mitigation actions to be implemented through local urban plans.
General description of the methodology	Based on the available hazard maps and on back-analyses, the different areas prone to the mud flows are defined. In the two types of identified hazard areas (impact and mud deposit), the exposed elements of any given spatial reference unit (census unit) are identified. The selected exposed elements are population, urban fabric, productive activities, public activities, infrastructures, agricultural areas, forests. For the linear, such as roads and railways, and areal elements exposure and vulnerability indicators are applied in order to obtain a relative and not aggregated assessment.
Assessment procedure	In each census unit, indicators of each exposed element are applied. The values obtained are ranked into 4 classes (low, medium, high, very high) through a "natural breaks" statistical method and a score, with values from 1 (low) to 4 (very high), is assigned to each class. For each exposed element, the final vulnerability level is defined as the sum of the assigned scores of each indicator, ranked into 4 classes.
Main indicators of territorial vulnerability	For the exposed urban fabric, apart from indicators describing physical vulnerability, two indicators, specifically aimed at taking into account the territorial aspects of vulnerability, are defined: the accessibility index, related to the minimum real distance from the gravity centre of each census unit to the point of access to an urban highway; the permeability index which depends on the length of road network, broken down to road classes, and on weight coefficients related to the average width,

	gradient and regularity of the road network.
Input data	The assessment is implemented in a GIS environment composed of areal elements, corresponding to census units, and linear elements, corresponding to infrastructure networks. The input data are both statistical data and data obtained by cartography, aerial photos and *in situ* surveys.
Example views	

Assessing and Mapping Neighbourhood Vulnerability to Natechs: An Italian Research Work developed within the UNINA-DIPIST Activity Programme 2005-2008

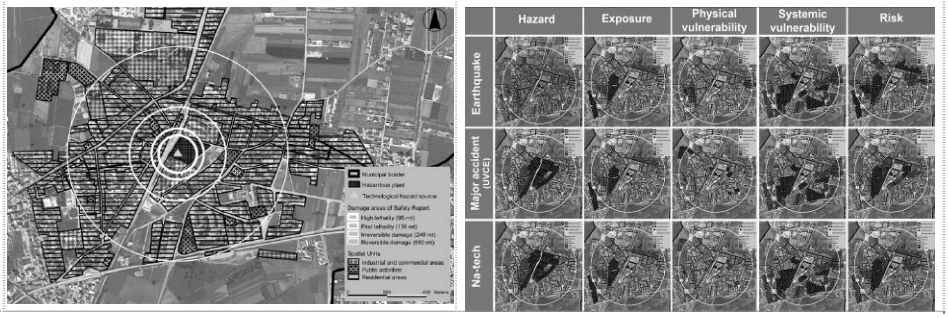
(UNINA / Di.Pi.S.T. 2008; Galderisi and Ceudech, 2008)

The methodology is again characteristic of the Italian strand that focuses on the concept of vulnerability of "territorial systems" for the purpose of optimizing risk mitigation (in this case protection against Na-techs) through spatial planning. The specific case considered is UVCE triggered by seismic event. The following Table 6 summarizes the basic features of the methodology.

Table 8: Neighbourhood Vulnerability to Na-techs

Type of hazard	Na-tech – Seismic event triggering UVCE
Scale	Neighbourhood - Urban area prone to Na-tech event
Territorial vulnerability approach	The vulnerability concept includes physical, systemic, organizational and social vulnerability. The method is focused on the first two components, since these are the most directly related to the spatial and functional organization of the city which are, in turn, the main field of action of land use planning and management. Systemic vulnerability mainly refers to the features of the

	territorial system which may influence the emergency response and management activities following the event, such as the accessibility to the emergency equipment in the impacted area.
Aim	A risk assessment method as a supporting tool for land use planning strategies aimed at reducing Na-tech risk in urban areas is developed.
General description of the methodology	The method allows planners to take into account all the individual Na-tech risk factors, measured through both quantitative and qualitative parameters, while providing them with a Na-tech risk index, useful to rank territorial units and to single out the priority intervention areas. The method is designed to process information generally available about hazardous plants (safety reports), natural hazards (hazard maps) and features of urban systems mainly influencing their exposure and vulnerability to Na-tech events. The necessity of dealing with heterogeneous data coming from several disciplines and related to different risk factors, and of considering "uncertainties", has motivated us to adopt fuzzy techniques to handle unquantifiable or linguistic information.
Assessment procedure	Based on available maps and information, the identification of Na-tech-prone areas can be carried out through the overlaying of the natural and technological hazard-prone areas. The latter can be divided into spatial units (SUs) based on census units, combined with the main land uses (residential, industrial, agricultural, etc.). Then hazard, exposure and vulnerability features for each SU have to be measured using fuzzy techniques and indicators normalized and processed through a MADM. The SUs are the "alternatives" of the MADM, while hazard, exposure and vulnerability indicators are the "attributes". The aggregate Na-tech risk index can be defined through the final rating of the attributes (average of the attributes' values). Priority intervention areas can be singled out through the ranking order of the alternatives with respect to the Na-tech risk index.
Main indicators of territorial vulnerability	Parameters related to systemic vulnerability refer to the accessibility to emergency equipment (hospitals and fire brigades), measured through the maximum distance between the gravity centre of the SU and the emergency equipments, and to the accessibility of the SUs by the rescue teams (only the residential ones). The latter (internal accessibility) has been defined through the normalized sum of qualitative judgments (high, medium, low), converted through fuzzy techniques into numerical scores, related to the urban fabric compactness (building density, presence of open spaces, etc.), the gradients of the secondary road network and its irregularity (orthogonality of crossroads, regularity of building plots, presence of winding roads).
Input data	The method is implemented in a GIS framework to easily provide planners with comparable maps able to figure out the hazard factors and the territorial features influencing the exposure and vulnerability and is fully based on common census data.

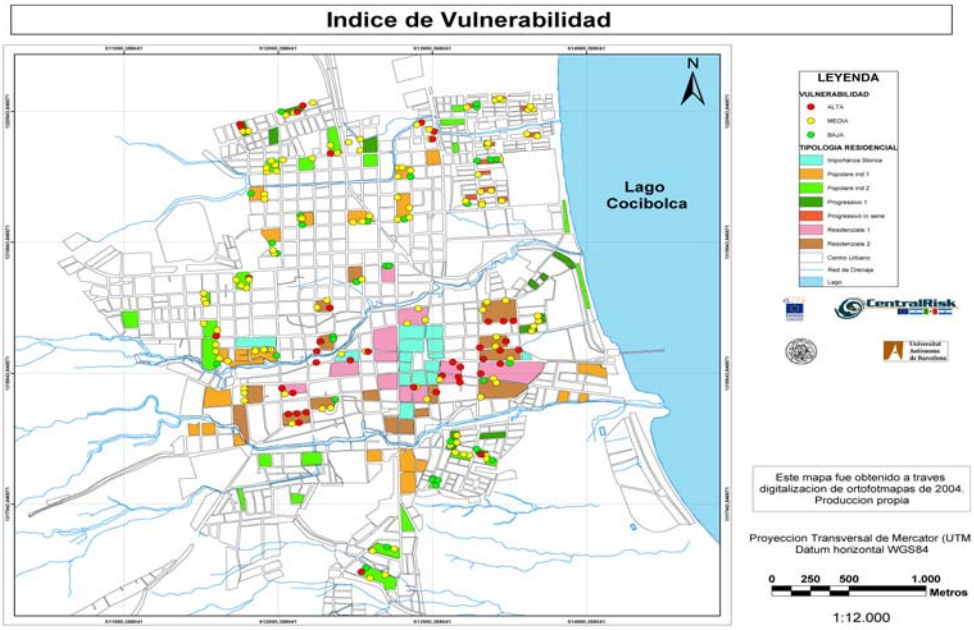
Example views	

<u>Urban Vulnerability Assessment in a Developing Country: Implementation of the POLIMI methodology within the Alfa funded project Centralrisk 2004-2006</u>
(Andrés and Rodriguez, 2008)

This case refers to an experience developed in the context of a EU funded project under the Alfa program of cooperation with Central America. It is shown how the methodology can be applied at relatively moderate costs also in developing countries, providing as an output interesting suggestions for retrofitting and mitigation.

Table 9: Urban vulnerability assessment in a developing country adopting the POLIMI methodology

Type of hazard	Seismic
Scale	Local scale
Territorial vulnerability approach	Vulnerability is interpreted as a complex concept comprising physical, systemic, functional aspects, related to the influence of buildings vulnerability on city functions
Aim	To provide a methodology for assessing the vulnerability of cities in developing countries
General description of the methodology	The methodology is based on a number of consequent vulnerability assessment maps and tables, addressing the vulnerability of buildings, structural blocks, roads, electric lines, water conducts, open spaces. It is shown how the methodology can be applied and provide useful mitigation suggestions in a developing country. In particular this work has been conducted in the city of Granada, Nicaragua, in the context of an Alfa funded project, Centralrisk.
Assessment procedure	Each aspect is addressed separately and then combined in the damage scenario assessment

Main indicators of territorial vulnerability	Indicators of vulnerability include the vulnerability of buildings, block of buildings, lifelines, public facilities. It considers also induced risks, due to the presence of industrial facilities.
Input data	The assessment is implemented in a GIS environment composed of point shaped elements, corresponding to buildings, open spaces and linear elements, corresponding to segments of the road and electric network. The input data are obtained by cartography, in situ surveys.
Example views	

Processes of Seismic Vulnerability Redistribution: Small Manufacturing Firms in Western Athens after the Earthquake of September 9/1999

(HUA research project 2003 and Sapountzaki 2005)

The whole approach has been based on two basic methodological assumptions:

(a) The breakdown of vulnerability into three constituent components as these have been perceived by Pelling (2003), namely exposure, resistance and resilience.

(b) The conceptual division of urban entities (or micro-territorial units or social domains) into two basic categories the producers and carriers of vulnerability.

As it has been already mentioned the approach does not assess territorial vulnerability to seismic hazard (of the area covered by eight Municipalities of Western Athens) with conventional methods (i.e. GIS, mapping etc). It outlines instead processes of transference of vulnerability from macrostructures to individual agencies and micro-territories, from institutions and the political-administrative system to individual building structures and private social entities, or vice versa from one social

domain to another and finally to the wider urban territory. Hence, the value of this approach as regards territorial vulnerability rests on the possibility it offers to locate the origins of territorial vulnerability and its dynamics (from and towards private and collective entities and institutions, higher and lower order spatial scales).

As regards the *Exposure* element of vulnerability to seismic hazard of SMFs in Western Athens, it has been documented by the study that this is more or less external and involuntary, i.e. beyond the control and coping capabilities of the entrepreneurs. Exposure in this case originated mostly from macro-structures and institutional factors: the location and structure of the wider Metropolitan Region, the vulnerable conditions of the physical structure of the western Athenian districts, the building networks that breach building law and land use regulations, the Governmental authorities that turn a blind eye to breaches of the law. The responsibility of SMFs for their overall exposure has been limited, owing basically to contraventions of health and safety rules in industrial premises. This has been evidently the case in rented accommodation. In such cases producers of vulnerability have been the landowners, the builders and all those whose actions had had harmful effects on the endurance of the industrial premises. Among the vulnerability producers are governmental agencies and administrative authorities, which allowed thousands of builders and private individuals to form and change for the worse the built environment of Western Athens. Thereby institutions and macro-economic structures in Greece produced over and there vulnerable urban districts and increased the exposure element of vulnerability of distinct social domains and micro-territorial units (Sapountzaki 2005).

Resistance in the case of SMFs was defined by the study in terms of their economic and other reserves that are not directly impaired by physical damage and which the firms can afford to draw on for their post-disaster recovery. (In this sense profitability, liquidity, the degree of dispersal of fixed capital, being a franchise or part of a chain instead of an individual, single location firm, the proportion of reserve funds vis-u-vis net fixed assets, outstanding debts, staff commitment and company reputation are all factors that affect the firm's resistance potential).

The resistance potential of the SMFs of Western Athens has been found by the study to be very low, due basically to their smallness. These were found to be individual, single location firms with low levels of profitability and an extremely restricted cash flow. They were saddled with debts, had a minimal number of long-term, regular employees committed to the firm and their fixed capital was more or less concentrated in one place. In this regard increase of the resistance potential depended on growth and development of the firm. It was proved then that resistance is an attribute that is determined primarily by the same the agency or the socio-spatial domain under stress. Surely, governmental institutions may increase or decrease resistance of firms and other agencies by means of public policies but resistance rarely is a property that is transferable from one agency to another within the context of the free-market regime.

By contrast with resistance the *Resilience* potential of SMFs in Western Athens proved to be high and most of them owe their recovery to this potential. This was related to flexibility and the capability of firms to operate with the help of informal practices that eliminate and externalize recovery costs. Such practices however may increase the vulnerability burden placed on interconnected agencies, subsystems or social domains. The study acknowledged as resilience assets the following availabilities: access to credit; multiple suppliers and customers and/or product markets that are geographically dispersed; family and social support networks; formal or informal insurance; rental status facilitating mobility; flexible forms of employment;

access to political and administrative mechanisms and trade union membership providing access to resources and political power. The SMFs considered were in a position to draw on several of these assets. According to the study the most important "asset" was the informal, semi-illegal character of the socio-economic environment within which SMFs operated. As a result the owner and family members could work extra hours, illegal immigrants could be employed, mandatory contributions did not have to be paid, activities and assets could be concealed and companies could function without a legal permit from the appropriate agencies (HUA 2003). These defensive practices facilitate externalization of recovery costs and act as a lifebelt for firms that otherwise would face definite closure The same spatial, institutional and socio-economic macro-structure that created exposure problems for SMFs lend them resilience through a diffused nexus of informal conveniences and relieved them of a part of their vulnerability (Sapountzaki 2005).

The recovery process after the seismic event of September 7, 1999 in Western Athens has been a series of successive comings and goings of vulnerability. When governmental institutions had the upper hand they attempted redistribution of vulnerability by favouring decrease of physical vulnerability alone and leaving socio-economic vulnerability to increase (i.e. to be transferred to disadvantaged social and economic agencies). Conversely when individual agencies assume the leading role in recovery they shift vulnerability burden to other (interconnected) agencies and the macro-structure of the city.

1.3.1.iv Adhoc Spatial Scales for Territorial Vulnerability to Floods

Considerations of territoriality and vulnerability to floods introduce the complication of hydrological/hydrographical territorial units and the scalar hierarchy which is commonly used in flood risk research, planning and management:

- river basin/catchment level (which may in some circumstances be international in composition);
- compound catchment level e.g. estuary planning units;
- sub-catchment level or shoreline (coastal) unit level;
- floodplain management units.

However, existing approaches to territorial vulnerability to floods are also commonly organized using the following scalar hierarchy:

- regional level (this may be equated with the river basin/catchment level)
- functional urban area or metropolitan level (may be located within or span compound catchments, catchments or sub-catchments)
- floodplain community level (may be located within compound catchments, catchments or sub-catchments); and
- individual household, individual business or individual person level (may be located within compound catchments, catchments or sub-catchments).

The research team of Middlesex University has elected to employ a combination of these scales, distinguishing between six levels which reflect our consideration of territorial vulnerability and floods. Methodologies are numbered in parentheses so that they may be cross-referenced to Table 7. Hewitt's (1997) methodology is not referred to further below because, although his methodology can be described as a human ecology perspective on disaster, his work addresses territories at all scales.

The identity given to the methodologies below is hardly ever clearly named and expressed in the publications to which MDX refers, and therefore the titles given to

these methodologies have been chosen by the MDX team. Note that the numbers in parentheses in the left-hand column of Table 10 refer to the same numbers also in parentheses in the following sections discussed below.

Table 10: Parameters/indicators according to scale of territory

Parameter or indicator used in methodology (methodology number)	River basin/ catchment / regional level	Compound catchment/ metropolitan level	Functional urban/ metropolitan level	Sub-catchment / shoreline unit level	Floodplain community/ floodplain management unit level	Individual household, business and floodplain occupant level
River discharge (1)	✓					
Floodplain type (1) (2)	✓					
Flooding type (1) (4) (6) (12) (13)	✓	✓				✓
Depth of flooding (1) (2) (6) (10) (12) (13)	✓			✓		✓
Speed of flooding onset (13)						✓
Physiographic & agro-ecological region type (1)	✓					
Degree of adaptation of building or settlement patterns and infrastructure to flooding (1) (2) (6) (10) (13)	✓	✓		✓		✓
Land ownership type (owner/tenant) (1) (9) (10) (13)	✓			✓	✓	✓
Degree of adaptation of cropping patterns to flooding (1)	✓					
Environmental factors (changes in river courses, human interventions, global warming (1) (6)	✓					
Dwelling type distinguished by construction materials used or no. of storeys (2) (10)	✓			✓		
Size of business enterprise (2)	✓					
Type of business enterprise (2)	✓					
Flood awareness (2) (6) (10) (12) (13)	✓	✓		✓		✓
Flood forecasting accuracy (6)		✓				
Flood warning	✓	✓		✓		✓

Parameter or indicator used in methodology (methodology number)	River basin/ catchment / regional level	Compound catchment/ metropolitan level	Functional urban/ metropolitan level	Sub-catchment / shoreline unit level	Floodplain community/ floodplain management unit level	Individual household, business and floodplain occupant level
response (2) (6) (10) (12) (13)						
Household characteristics (affecting health damage) (2) (7) (8) (9) (10) (12) (13)	✓		✓	✓		✓
Monthly income compared to monthly house rental values (7)			✓			
Existing health status (12)						✓
Incidence of diaorrhoeal disease & causes of morbidity (2) (7)	✓		✓			
Capital intensity of business enterprises (affecting flood damage) (2)	✓					
Linkage effects in the economy (2)	✓					
Urban sprawl and development, regeneration of floodplains (3) (6)		✓				
Co-location of premier banking and finance centre within floodplains (4)		✓				
Income inequality and social polarization (3) (9)		✓		✓	✓	
Public flood risk information accessibility and availability (3) (6) (7) (8) (13)		✓	✓			
Degree and effectiveness of institutional or community learning (3) (13)		✓				✓
Gender of motorists/drivers/ householders (5) (8) (12)		✓	✓			✓
Optimism bias of drivers (under-estimation of flood risk) (5) (8)		✓	✓			
Degree of flood		✓	✓			✓

Parameter or indicator used in methodology (methodology number)	River basin/ catchment / regional level	Compound catchment/ metropolitan level	Functional urban/ metropolitan level	Sub-catchment / shoreline unit level	Floodplain community/ floodplain management unit level	Individual household, business and floodplain occupant level
experience (4) (5) (8) (12) (13)						
Direction of change of flood risk management policy (i.e. increasing or decreasing the flood risk) (6)		✓				
Climate change (6)		✓				
Rate of deterioration of existing flood defences (6)		✓				
Risk of failure of flood defences (6)		✓				✓
Degree of organisation and effectiveness potential of emergency services (6) (13)		✓				✓
Population density (6) (9)		✓		✓	✓	
Homelessness (6) (12)		✓			✓	
Social deprivation (6) (12) (13)		✓			✓	✓
Flood insurance ownership (6) (12) (13)		✓				✓
Access by the poor to resources (e.g. low-interest loans) (7) (9) (11)			✓	✓	✓	
Influence of power alliances (9) (10) (11)				✓	✓	
Ethnic group or composition (12)						✓
Influence of apartheid (11)					✓	

River basin/catchment/regional level

Three empirical assessment methodologies are represented in the conceptual approaches identified in 1.2.3. The first is an integrated "*Man and Environment" methodology (1)* reflecting geographical origins, in which the "physical setting" (i.e. river catchments, flood plain types, flooding types, physiographic regions agro-ecological regions) are related to "human use" systems including settlement and infrastructure, population, land use, cropping patterns and political responses to floods (Brammer, 2000). Vulnerability is viewed as an outcome of these "overlays", and the methodology is designed to generate an "explanation" of the plight of the relevant territory e.g. Bangladesh with regard to flooding. The definition and use of

the concept of vulnerability in this case is very general and the explanation of vulnerability is shallow. The methodology requires national level data (e.g. on physiography, flood types etc.) broken down into mapped regions, a mix of quantitative and qualitative data (e.g. on cropping patterns, flood depths etc.) most of which are available in reliable form from Flood Action Plan outputs.

The second is a *"Micro and macro economic methodology" (2),* focused upon three urban areas but subsequently generalized to the regional/national level (Islam 2005, 2006). The origins of the methodology are part geographical (land use studies) and part applied economics, being a blend of the two. With regards to Bangladesh, the author's aim was to contribute to an understanding of urban flood loss potential and its regional and national impact potential in the country, and the analysis benefits the broad drive to reduced flooding in that country. Economic values representing flood losses to major land use types (e.g. dwellings, businesses) are used to assess vulnerability to flooding of different socio-economic groups in Bangladesh. Subsequently the vulnerability of the urban economy to floods is modeled using input-output methods to determine the differential vulnerability of economic sectors and urban areas. The methods have many strengths (the data collection and analysis is almost heroic) and few weaknesses, except that only 3 urban areas are used to generate the national assessment and some data reliability issues arise. Quantitative data are required at individual household and business level, and are gathered from primary survey sources, but the macro analysis uses nationally available quantitative data on flows and stocks. Output data are impact values for floods in Bangladesh at different scales, local, regional and national.

The third is a *Planning methodology (3)* used in England, but also we believe in many other countries, which employs the river catchment as a basis for examining flood generating processes, exposure, vulnerability, resilience and other dimensions, and for constructing flood risk management plans which partly aim to reduce vulnerability (but also to reduce flood risk, flood exposure and so on).

Compound catchment / metropolitan level

Three quite different empirical assessment methodologies are represented in the conceptual approaches identified in 1.2.3. The first is an integrated *"Man and Environment" methodology (4)* reflecting geographical origins in which physical setting and human use systems are analysed to uncover spatial and temporal patterns of risk, exposure and vulnerability in the context of a "Mega-city" (e.g. London, Seoul). The London mega-city spans at least 8 major river catchments. The authors (Parker, 1999a; Kiw-Gon Kim, 1999) sought to deepen understanding of the special (i.e. unique) risks and opportunities which mega-cities and their governments face in combating floods. The methodology suffers from lack of data at the mega-city level, and the incompatibility of data at the intra-governmental unit level, and a lack of GIS representations of these data for mega-city spatial scale (although in the case of London this problem has receded since the London study was completed). Data are required, for example, on the number of properties and lengths of transportation links of different types in floodplain units across the mega-city with accurate altitudinal data for each. Data is also required for the population characteristics of discrete floodplain units but these data are only just becoming available in London, and not for the entire mega-city. Output data include qualitative assessments of trends in risk, exposure and vulnerability in the past and future (see Parker and Penning-Rowsell, 2005).

The second approach is Ruin et al's (2007) "*Cognitive mapping and interview methodology" (5)* employed to "map" and understand French motorists' decisions about driving (or not) and route-taking through compound catchments in the Gard department of southern France. The intent was to develop output data and understanding which can be used to improve public education and transportation planning to make motorists safer, and the research generates some very useful findings. The methodology has no apparent weaknesses with the exception that the sample size could have been larger. Output data are cognitive maps, binary and qualitative data.

The third approach is the TE2100 flood risk management plan: the Thames estuary includes the catchments of numerous rivers and streams as well as the Thames (Environment Agency 2007, 2008). The methodology is a "*Fully integrated, multi-dimensional and multi-disciplinary risk assessment with embedded vulnerability assessment methodologies" (6).* The anticipated results are a comprehensive flood risk management plan focused upon reducing flood risk (through preventative and adaptive strategies) and managing economic and social exposure and vulnerability to floods to 2100 and beyond. It is difficult to identify shortcomings in this vast study at this stage, prior to final plan publication, but data deficiencies are unlikely to be problematic since so much effort has gone into generating the data required. Data used in this methodology are multi-faceted (i.e. "you name it and it is available in this study"), but the vulnerability data include very detailed population, social, economic and property level data for over 20 "policy management units" which comprise the estuary study area. Data is predominantly qualitative and is represented in tabular and GIS format. About 20 flood risk indicators (quantitative and qualitative) are used and monitored and comprise one set of outputs. Other outputs include investment plans, infrastructure development plans, and many other options plans as well as comprehensive stakeholder guidance.

Functional urban or metropolitan level

Two assessment methodologies are representative of this level of analysis. The first is the study by Zoleta-Nantes (2000) of vulnerability to floods in Metro Manila. This is a *"Social geography survey methodology" (7)* in which a sample of respondents from the urban poor sector of the metropolis are subjected to in-depth interviews about their experiences; with this survey being embedded within a metropolitan-wide social geography analysis of poverty, income, morbidity, coping strategies and government policies. The results are intended to shed light upon the plight of the urban poor in regard to flooding and related poverty-reinforcing processes. The methodology is limited by the smallness of the sample (39 respondents) used for the interviews although extracts from these interviews generate interesting and illuminating output data, qualitative in nature. The input data are interview records and secondary sources data on income and morbidity levels. The second case is the Drobot *et al* study of car driver perceptions and reactions to flooding in Denver, Colorado and Austin Texas. Respondents come from all parts of these metropolises. The methodology is a *"Social-psychology-based quantitative statistical analysis methodology" (8)* based upon responses from thousands of interviews placed on the internet in each city requesting responses from car drivers. Although the sample size is very large in this case, the respondents are self-selecting which can lead to bias in the results: a point addressed by the authors. The data are subjected to quantitative statistical analyses to try to determine significant statistical correlations, for example between age or gender and driving behaviour. The ultimate aim of the authors is to contribute to improving educational programmes to improve driver safety.

Sub-catchment or shoreline unit level

Two cases from the conceptual approaches identified in 1.2.3 represent methodologies used at this scale. The first is Winchester's (2000) study of agriculturalists in a delta-island in south India. Winchester's perspective is that the vulnerability of these people to floods can be explained by the inter-play of closely linked political and economic circumstances which have their roots in historical and present day land ownership and resource access inequities. He employs a *"Structural and policy analysis methodology"' (9)* which focuses upon the alliances which have dominated the local political economy and which controls access to land and resources. His aim is to demonstrate how empowering organizations (such as a non-conventional bank) can be incorporated into flood mitigation to overcome these ingrained structural disadvantages afflicting the poor. Winchester's data is largely qualitative, being derived from living and working amongst the poor and progressively interviewing them, and also partly quantitative (e.g. estimates of flood losses, distribution of land ownership and other assets). The strength of the study is that it powerfully demonstrates that vulnerability can be helpfully approached by a study of power alliances and their impacts. There is no obvious shortcoming with the possible exception of the subjectivity brought to the study by Winchester's world view, but this is also a strength. Outputs are in the form of qualitative policy prescriptions.

The second case in Tunstall *et al* (1991, 2007) studies of the socio-economic impact of flooding in England and Wales undertaken in a variety of sub-catchments and subsequently assembled into a "national study" for the FLOODsite project (although the national study is simply the aggregation of the individual sub-catchment studies). Tunstall *et al*. employ a *"Social survey methodology" (10)* which comprises lengthy and detailed interviewer-administered questionnaires targeting those who have been recently flooded or who are at risk from flooding. The anticipated benefit of these studies has been that they inform flood risk management policy-making in the UK by illuminating the social, economic and other impacts of flooding upon people's lives. Thousands of questionnaires were collected from a range of different surveys. Data inputs are socio-economic characteristics of respondents, and data on their flood perception and knowledge, impacts of floods on them and their household etc. A shortcoming in aggregating the data is that the survey instruments evolved over time and are not always entirely compatible or consistent from one study to another presenting some aggregation and interpretation problems. In addition, the results are not displayed through a GIS. The strength of the methodology is that it canvasses the views of those at the sharp end of flooding – individual flood victims – breathing "reality" into flood management policy. Data are analysed using SPSS software and are presented in output form as tabulations and correlations.

Floodplain community/floodplain management unit level

One of the conceptual approaches in 1.2.3 represents the methodology used at this level. Wisner's (2000) analysis of the African township called Alexandra Township uses a very similar methodology to that employed by Winchester above: a *"Structural and policy analysis methodology" (11).* Alexandra is a small part of Johannesburg and partly occupies the floodplain of the Juksei River. Wisner uses essentially the same data collection strategies as Winchester and the pros and cons of his approach are as those for Winchester, as are the other aspects of this methodology.

Individual household, business and floodplain occupant

Two of the conceptual approaches in 1.2.3 exemplify the individual, basic building-block, level. The first is the series of health vulnerability studies by Tapsell and colleagues (e.g. Tapsell et al., 1999). The methodology is a *"Social survey methodology" (12)* although *"Focus group interviews"* and a *"Self-report health questionnaire" and a "General Health Questionnaire"* were also administered. The intended benefit of using these methods was to reveal hitherto poorly understood impacts of floods on individual householders, and an important part of the study was comparison of effects over a period of several years. The identification of health effects relies upon a self-reporting approach by those affected by floods, rather than upon a research using a flooded group of individuals and a similar non-flooded control group. Data collected include socio-economic characteristics of respondents, their experience and perception of floods, and the economic, social and health impacts of floods. Data are both quantitative and qualitative. Outputs are extracts from interview transcripts and tabulated data. The second case comprises the research of De Marchi et al. (2007) and Steinfuhrer and Kulicke (2007) in the Italian Alps and in the Elbe catchment of Germany. Again *"Social survey methods" (13)* were employed with interviews focusing upon local villagers and individual householders in the main, but the research is cast within a socio-economic profile of these settlements including data from secondary sources on population, income and education characteristics.

The present section indicated that there are various points of view and assessment possibilities as regards territorial vulnerability. The parameters and indicators used vary to a large extent. The query that is raised is whether these parameters and indicators are representative, measurable, stable and reliable. These are the issues involved in the discussion that follows.

1.3.2 Appropriateness of Parameters / Indicators Used in Assessment Methodologies

1.3.2.i The Disaster Risk Index model

The Report by UNDP (2004) acknowledges some of the weaknesses and limitations of the DRI and the respective vulnerability assumptions and indicators:

- The DRI is not a predictive model. The risk maps provided by the research allow for a comparison of relative risk and relative vulnerability between countries, but cannot be used to depict actual risk for anyone country. Sub-national risk analysis would be required to inform development and land use planning at the national level.
- The DRI represents the risk of death only; hence vulnerability with regard to human losses. This fact has a series of repercussions. The disasters causing enormous social and economic losses without serious mortality are not captured by DRI. Besides disaster risk trends in industrialized countries are not addressed by mortality calibrated models. Consequently, DRI only represents risk to loss of life and cannot be inferred to represent other physical, social and economic aspects of risk.
- DRI examines risks and vulnerability associated only with large and medium scale disasters. The publicly available global data on disaster impact concern only large and medium scale disaster events, defined as those involving more

than 10 deaths, 100 affected and / or a call for international assistance. Since DRI is based on this data it does not represent risk associated with small-scale and everyday disasters.

- DRI represents risks associated only with earthquakes, tropical cyclones and floods. While primary hazards may trigger a range of secondary hazard events (for instance landslides and fires in the case of earthquakes) their impacts are not captured by DRI even when the majority of loss is associated with the secondary hazard types that have been triggered by the primary event.
- DRI represents disaster risk and vulnerability only for the period 1980-2000.
- DRI tested vulnerability indicators only from available global datasets. The variables that could be tested were only those available in global datasets. However, there might be other variables relevant to vulnerability and risk but for which no global datasets were available at the time of production of DRI.
- DRI does not include indicators reflecting disaster risk management and reduction.

An external observer might raise some other issues as shortcomings of DRI with regard to vulnerability conception. Indeed the whole rationale carries the problems of the first school of vulnerability approach (pre-dominant in the technical literature). First the multiplicative model followed by the equation of risk and vulnerability too is based on arbitrary assumptions. Secondly, vulnerability and exposure are dealt with in the equation of risk as independent factors; the underlying assumption is that they encounter each other only in the case of a hazardous event whereas the latent attitude of vulnerability is activated to produce adverse impacts and losses. A third problem is that vulnerability is treated as an average attribute in time and space, as an attribute without locus, without peaks and recessions in time and space. Indeed vulnerability of the period 1980-2000 is evaluated on the basis of the mean values of the determinant socio-economic parameters during a period that spans 21 years. Besides, vulnerability is evaluated on the basis of the national average of the determinant parameters. As a result the producers and carriers of vulnerability are out of view and so are the mechanisms of increase, decrease and transfer of vulnerability. Although DRI rationale acknowledges vulnerability as a dynamic condition yet it identifies vulnerability with a numerical value that characterizes in a uniform way a whole country and rather for a period of 21 years. The fact that the origins of a country's vulnerability may rest on distant, exogenous, supra-national decision centres and globalization pressures is disregarded. The DRI methodology makes vulnerability and risk a purely geographical parameter that can be represented on maps as a two-dimensional property; in the real world however, vulnerability is a constantly changing, multi-dimensional attribute turning easily from a technical issue to a social, economic, political, environmental and so on. Vulnerability might not be captured that way because the mechanisms that produce, increase, decrease and expand it remain obscure. Furthermore, it may be true that exposure is the inevitable outcome of vulnerability and therefore a variable dependent on vulnerability.

1.3.2.ii The model of the ESPON Hazards Project

The indicators used in the ESPON methodology witness:

- An emphasis on the coping capacity content of vulnerability
- A perception that identifies the "damage potential" element of vulnerability with physical exposure. Inherent resistance capabilities out of mitigation - public and private- strategies are totally ignored (for instance urban and building design properties making cities and buildings resistant to

earthquakes, floods etc are completely out of view; also insurance mechanisms both formal and informal). Vulnerability is evaluated in terms of the exposed (to hazards) economic value, the exposed inhabitants, the exposed hotel beds, exposed natural and cultural heritage. Whether these exposed elements have got the resistance or resilience capability to avoid the expected adverse impacts does not matter to the methodology at all.

- Vulnerability as regards economic losses is equalized to vulnerability with respect to human losses and mutual interdependencies and amplifier effects are disregarded.
- The immaterial aspects of vulnerability are not considered at all.
- Systemic vulnerability is bypassed by the methodology.

Besides and as Kumpulainen (2006) puts it the challenge after ESPON project is the hazard specific nature of vulnerability. In particular, Kumpulainen proposes two different approaches for the future: (a) the hazard-centred approach, meaning consideration of vulnerability indicators for a chosen hazard and (b) the region centred approach, meaning consideration of the hazards first and then the hazard-specific vulnerability of a chosen region.

1.3.2.iii Physical Vulnerability at Mega-city Scale: The Munich Re Approach

The approach is concerned primarily with the physical aspect of territorial (urban) vulnerability and to a lesser degree with the institutional one. Other dimensions of territorial vulnerability are absolutely missing. Besides, vulnerability is considered in pre-disaster terms alone, a more or less stable attribute that reflects its definition as "the pre-disposition of a city structure to be affected by a hazard and suffer direct damages and losses". The approach does not capture the dynamic nature of vulnerability, the fact that it undergoes rapid changes especially after a catastrophic event (during the successive phases of the disaster management cycle).

Hence, post-disaster resilience and coping capacities are left out of the evaluation and so is vulnerability during the emergency, relief and recovery phases. The approach puts attention at physical damages in the built environment and primary losses but does not take thought of subsequent secondary losses and rates of recovery and reconstruction. In other words the approach is featured by an inherent and implicit assumption that vulnerability under consideration is city vulnerability with regard to expected, direct material losses.

1.3.2.iv The approach of Seismic Vulnerability of Small Manufacturing Firms in Western Athens

The approach does not assess SMFs vulnerability in quantitative terms with the help of some determinant variable parameters. Besides, the whole rationale is based on the conviction that social structures and agencies within a broader urban territory can be compared severally on the basis of their exposure, resistance and resilience potential; but they cannot be compared on the basis of their composite vulnerability potential. This is because exposure and resistance are relatively stable features while resilience is not (as it is the potential for post-disaster action and externalization of recovery costs). The approach traces instead and only in qualitative terms the post-disaster changes of exposure, resistance and resilience potential of the SMFs, other social micro-structures and the wider urban territory. Moreover, it arrests the initiators of these changes: the same the SMFs (which manage to lend exposure to other micro-structures and the wider physical structure of the district when they

assume themselves their own recovery) or alternatively public institutions (which aggravate SMFs' and other weak socio-economic agencies' vulnerability in order to rescue the built environment and the interests of the owners of landed property).

It is evident that the methodology does not offer the accuracy and the detailed rating of vulnerability levels as do the more technical quantitative processes.

1.3.2.v The approaches of Territorial Vulnerability to Floods

Table 7 in section 4.3.1.iv is a correlation matrix demonstrating the relationships between parameters and indicators of vulnerability used in methodologies employed at the six territory scales distinguished in the same section. A very wide range of parameters and indicators is used in flood vulnerability methodologies. They may be categorized into four types:

1. physical flood-producing or describing parameters (e.g. flood type, depth etc.);
2. receptor or human use system parameters (e.g. socio-economic composition of households);
3. the potential effectiveness of failure of flood risk mitigation measures (e.g. flood barriers); and
4. social, political or institutional structures or processes (e.g. power alliances; effectiveness of flood management institutions).

Those methodologies that are strong on 1 tend to be very weak on 4 and this reflects deep "establishment/non-establishment" differences in world view, and is to some extent also correlated with deep differences in "engineering/non-engineering" perspectives which partly have disciplinary and power alliance explanations. However, indicators of political processes are general rather than specific and the identification of more specific indicators appears to require research. The same may be the case for institutional structures but further progress appears to have been made with indicators for these.

1.4 The Impact of Geography and Spatial Development on Territorial Vulnerability

1.4.1 Insular and Remote Areas

In this section we present an approach developed for the estimation of seismic vulnerability of Aegean islands in a pioneer Greek research project (N.K.U.A., UA and MA 1998; Delladetsima et al., 2006). In doing so we followed our initial guidelines for this chapter which specifically mentioned the case of insular and remote areas, to be included in this section.

The conceptual approach to the vulnerability of islands

The approach attempted to respond to the following key question: What are the distinct features determining an island risk context and how do these influence an earthquake disaster situation? The cases of Chios, Kos and Nissyros shed light on some of these features. The three islands differ in terms of their position in the administrative pyramid and structure of the respective governing mechanisms,

demographic composition, human geography, building stock and settlement structure, accessibility / transport conditions and finally, emergency institutions.

All of the above-mentioned features have a marked geographic/physical dimension as well as a social / organisational one. It was considered that through this conjunction an effective vulnerability risk analysis and seismic safety protection policy methodology could be constructed. The approach was designed with sufficient flexibility to incorporate physical and social components and the ability to adjust to the distinctiveness of each insular entity.

The framework for developing such a methodological approach was defined by two different but overlapping perceptions or conditions, each of which reflects a basic situation vis-à-vis the pattern of response by an island to an earthquake hazard. More specifically, the island was seen both (I) as a "closed" and (II) as an "open" system.

Condition I (the island as a closed system)
Each island is a self-contained entity that is called upon to cope with an earthquake emergency without external help for many hours or perhaps days. In this case, the approach centres on a view of the island as a "closed system", in the sense of optimising the ability of its components (human and technical resources and infrastructure) to deal with emergency needs. To this end, the elements at risk in the social and built environment should be examined in an integrated manner.
Consequently, emphasis is placed on:
a) Identification of inherent vulnerable conditions on the island (population groups, an aging building stock, dwindling settlements and a poorly designed/maintained road network); and
b) An evaluation of possible losses and needs, as well as of the operational and organisational adequacy of the response system (services, institutions, human potential and infrastructure) and coping capacity (or the ability to use existing resources in an effective reaction that can reduce disaster losses), which are directly or indirectly part of the overall seismic safety policy (which is primarily determined by existing critical emergency functions and the island's institutional adequacy to tackle emergencies). This two-fold emphasis emanating from the closed system condition aims to establish the correlation—in spatial and operational terms—between the local coping capacity system and the exceptional demands that are manifested during any earthquake disaster.

Condition II (the island as an open system)
In the event of an earthquake disaster, the "open" system island should be able to maximise its ability to receive and use external support effectively, such as human and technical resources and water and food supplies, and ensure that the population can be evacuated to the mainland or to neighbouring islands if deemed necessary. Thus, with respect to an open system island, attention should focus on assessing the vulnerability and capacity of components such as:
• Points of entry and exit (airport and harbour installations);
• The existing formal (or informal) distribution/emergency network;
• Regional/national accessibility conditions on the island; and
• The potential of its communication and information technologies.
Potentially, the operation and strength of the open system is "tested" during the latter stages of an emergency response period and short-term recovery phase. It is clear that effective vulnerability analysis and policy could be structured by integrating elements from both the closed and open system (see Figure 4).

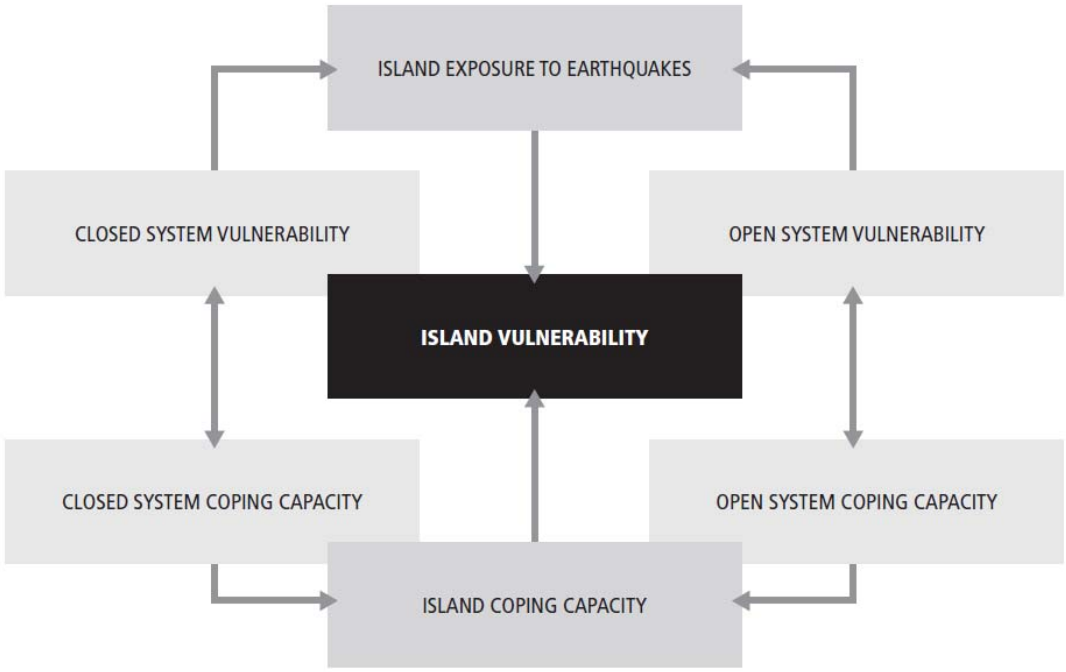


Figure 4: Island vulnerability and coping capacity

There is a need for a methodology for an island setting that is capable to grasp the complexity of the conditions involved (including economic, operational, physical and social ones), which together determine catastrophic potential. This implies, as a precondition, the ability to generate constant knowledge of the changing environment and to identify vulnerability fluctuations all over the island territory. In this respect, a major matter of concern pertains to the identification of the appropriate components that more accurately reflect the operation of the island as a "closed system" and "open system" in an earthquake emergency.

An outline of the methodology

The proposed methodology based on a reading of the Aegean setting, identified the following island components as determinant of vulnerability (see Figure 5):

• In the case of the "closed system" analysis, the building stock; the transportation network; the composition and distribution of the population; and location of vulnerable functions.

• In the case of the open system analysis, only the points of "entry and exit", structural efficacy and broader regional accessibility conditions.

In turn, the key coping capacity factors of the closed system were defined by the location and effectiveness of critical functions and the efficacy of the local governance system (including non-governmental organisations –NGOs-, voluntary agencies and professional bodies). Meanwhile, the open system coping capacity referred basically to population evacuation and the island's ability to receive and distribute external aid. Shortcomings in available data at the scale of the study, i.e. at the level of municipality, were a key concern that had to be tackled. An effort was made to develop appropriate approximate indicators that utilize data from the National Population and Building Surveys. Moreover surveys were conducted by disseminating questionnaires to the Municipalities and main agencies within the island governance system.

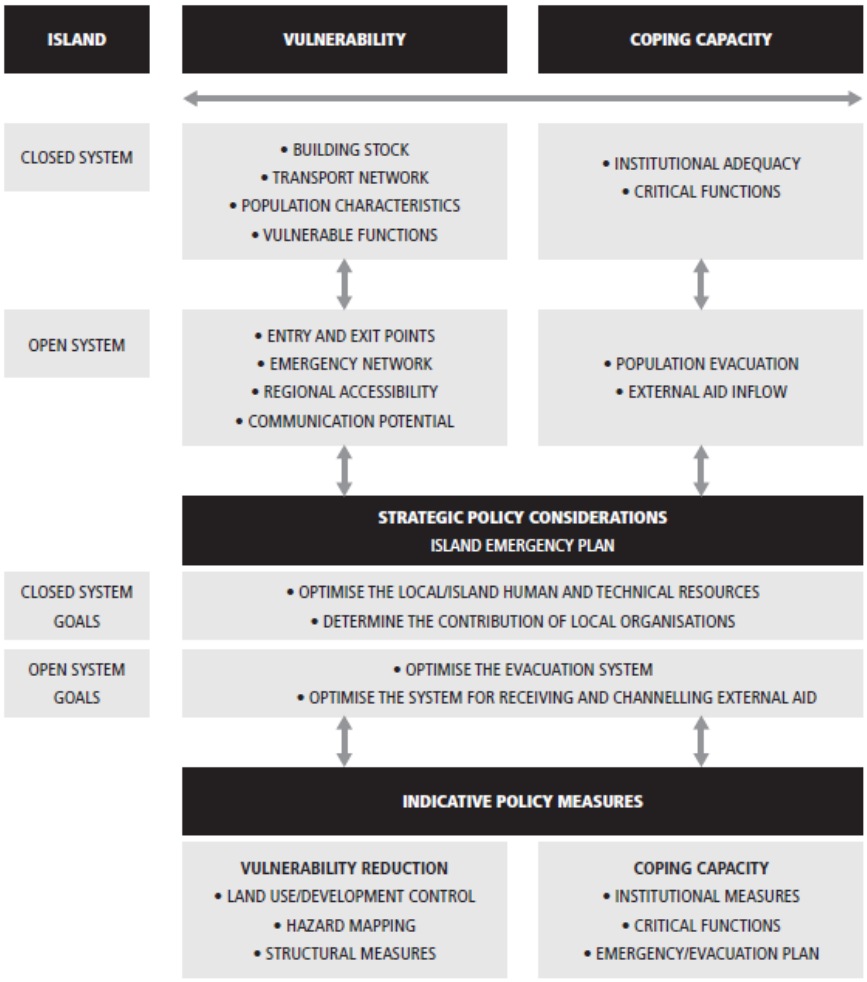


Figure 5: Island vulnerability and coping capacity components as well as policy considerations

In the following paragraphs we summarize the project's approach to the estimation of key parameters, especially in connection with the condition of islands as closed systems.

Vulnerability of the closed system - Vulnerability of the building stock

Key features of many islands and relevant considerations:

- Predominance of small settlements,
- Old, poorly maintained building stock, and
- Declining population,
- Traditional urban structure and building stock (irregular and narrow roads, inadequate open spaces, old non-engineered constructions),
- Abandonment of buildings over the past 20 years,
- Speculation-driven building construction,
- Implications for increased seismic vulnerability,
- Secondary effects of building damages (road blocking etc),
- Critical conditions during tourist season. .

Methodological implications:

- Distribution, age and use of building stock shape emergency demand patterns and impact on the ability of the system to respond,

- The building stock should be examined as an all-encompassing vulnerability component determining potential losses, emergency needs and response ability,
- Vulnerability assessment of existing buildings should serve this purpose and be based on locally defined criteria and observations, housing surveys and inputs (technical reports), especially in small settlements,
- This is a costly and time-consuming approach,
- Adoption of a rough approach,
- Buildings designed and constructed in accordance with seismic codes are expected to offer a minimum level of seismic safety,
- Buildings constructed before the enforcement of the 1959 Seismic Design Code are old and suffer from low maintenance and abandonment especially in remote settlements,
- Percentage of non-engineered buildings in each municipality served as an approximate indicator of seismic vulnerability of the building stock.

Vulnerability of the closed system - Transportation network—internal accessibility
Key features and methodological implications:

- Internal accessibility and transportation network as key components of island vulnerability,
- Vulnerability of road system in terms of carrying capacity, geometry, physical conditions and traffic flows (distinction between "normal" periods and "potential crisis situations"),
- Importance of peak automobile flows, especially in the main towns and in the tourist season,
- Attention to roads crossing settlements, because of danger of flow disruption as a result of building collapse or falling structural elements.

Vulnerability of the closed system - Population characteristics and demographic fluctuations
Key features and methodological implications:

- Effect of demographic composition on overall vulnerability, especially of ageing population and percentage of dependent persons,
- Effect of uneven spatial population distribution,
- Changes of the islands' human geography in the summer due to domestic and international tourism and returning non-permanent residents,
- Lack of earthquake experience and seismic awareness among tourist population,
- Resulting vulnerability conditions and human geography fluctuations require a detailed examination of population growth during the tourist season, spatial concentrations of tourist population and of its country origins.

Vulnerability of the closed system - Vulnerable functions
A crucial island vulnerability component was the location and structural efficacy of vulnerable functions, i.e. those characterized by:

- High periodical population concentration, daily and/or seasonally (cinemas, theatres, sports venues, and retail, education, entertainment and religious buildings);
- Special nature (non-voluntary) of the occupancy of space (nurseries, primary schools, elderly care homes, orphanages and detention centres);
- Increased potential to generate domino effects, such as explosions and fires (fuel depots, oil stations, inflammable material storage sites and chemical facilities); and

- A high degree of importance as economic, administrative and cultural functions for the survival and reconstruction of the region (productive / economic units, administrative services, historical and archaeological sites, museums, libraries and historical archives).

Finally as *Coping capacity factors of the closed system* were assumed Institutional Adequacy—Emergency Planning and the Critical Functions. In the case of the *Island as an open system* as determinant vulnerability factors were taken the Capacity and Adequacy of island points of entry and exit, the Emergency distribution network, Regional accessibility, Communication potential. As determinant *Coping capacity factors* of the open system were supposed to be Evacuation capacity of non-permanent population and External aid inflow. Figure 5 presents the geography of key features of the case study islands seen as closed and open systems. By taking into account the vulnerability and coping capacity deduced from the analysis of each island, some policy guidelines were drafted based on objectives and priority-setting criteria.

Appropriateness of the methodology

The method attempted to highlight the importance of the island setting as a risk context and in turn as a specific mitigation and emergency planning field. In this respect, it sought to present a methodological framework that might be applied consistently to studies of insular areas. Islands are indeed highly particular and diversified risk contexts. Different features emerge that influence potential seismic loss, including coping capacity and of course seismic safety policy needs. This clearly highlights the need for a diversified method to deal with vulnerability analysis and seismic protection planning strategy in island environments. Specifically, what is required is a method that, on the one hand, defines a broader common framework that can be shared by islands (necessary for increasing analytical knowledge and policy effectiveness), and on the other, can be embedded in distinct island contexts (grasping the exceedingly varying institutional, socio-economic and physical conditions). Given also the multidisciplinary nature of the above purpose, the suggested methodology introduces a broader comparative framework for islands for both analytical and policy-making purposes. The strong and at the same time the weak point of the approach is that it centres on the isolation of islands. This substantiates the assumptions of the island as an “open system” and a “closed system” that lead to scenarios that are jointly analysed and produce specific earthquake mitigation and emergency management policies. Although isolation is a core issue in earthquake policies in islands it might not always be the most significant one depending on the context and specific case (figure 6).

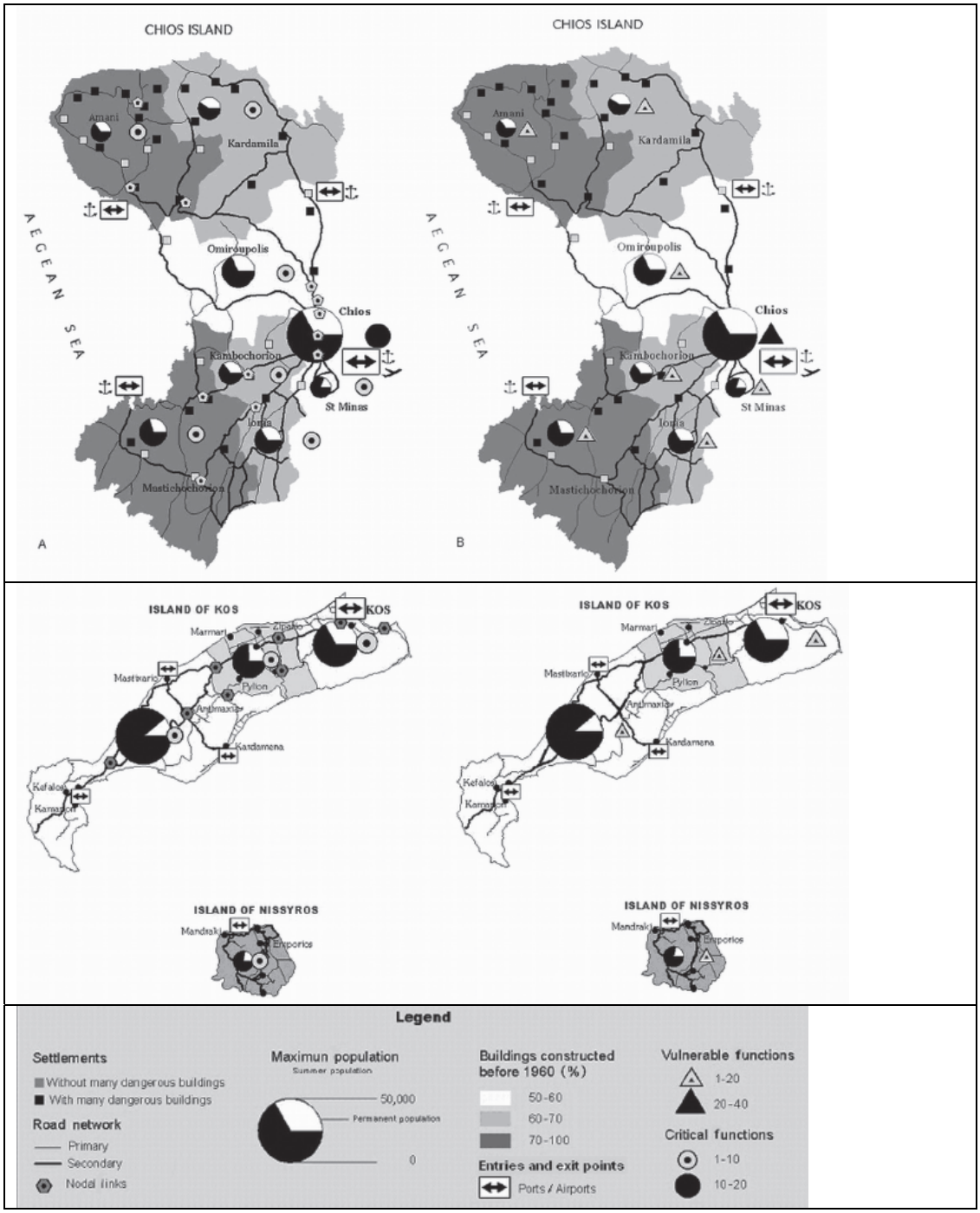


Figure 6: Chios, Kos and Nissyros islands as closed (A) and open (B) systems

Based on the assumption of the island operating as a “closed system” on the one hand and as “open system” on the other, the methodology combines qualitative and quantitative approaches in a rather qualitative manner leading to a general diagnosis of vulnerability and capacity features of the islands. Although the methodology claims to respond to a holistic earthquake policy targeting both mitigation and emergency goals it follows mainly a “potential demand-capacity to respond” approach that corresponds mainly to the emergency phase. There is still a long way towards quantification and precision and even more towards a refinement of assessment methodologies of capacity and vulnerability of specific elements in consideration.

Among them one should mention earthquake vulnerability of buildings, vulnerability and capacity of inland transport system and social vulnerability.

An interesting aspect of the methodology is that it considers in a relatively balanced manner vulnerability and capacity. Yet the dynamics of vulnerability and capacity and their trade-offs can be further investigated. The same applies as regards the dynamics between different administrative and territorial scales in the island and externally. Finally, the methodology is intended for an earthquake policy strategy for islands; nevertheless it hardly involves the key players in policy making and implementation in manners other then furnishing information.

1.4.2 Spatial Pattern Factors affecting Territorial Vulnerability to Floods

Within the literature outlined in section 1.2.3 there are more than a few contexts and patterns of spatial development because of the range of territorial scales and cases visited. This sub-chapter is, therefore, selective and discusses some of the impacts (which are believed to be key ones) that patterns of spatial development have on territorial vulnerability to flooding without attempting to be comprehensive.

The case of the London mega-city (Parker 1999a; Parker and Penning-Rowsell 2005) illuminates the impact that urban containment policy may have on exposure and vulnerability to natural and technological hazards. In England a “green belt” policy was established in the late 1940s to stop urban sprawl into the countryside surrounding cities such as London, and to stop urban settlements from further coalescence. 60 years later the impact of this policy is clear to see: higher density development or “compact” cities, and increased intensity of development of na-tech hazard zones in London often in close proximity to the more vulnerable sectors of the population. These impacts have been explored further in the context of urban containment policies in the USA and Europe (Burby et al., 2001). There are many other forms of protection of natural areas and habitats in the UK which may, in some cases keep development out of river corridors, but they all have the affect of increasing density of development. The latest chapter in London’s development is the decision to regenerate the east of London (traditionally the poorest and most run-down part of London) through projects including the Olympics 2012 project and the Thames Gateway project which will lead to the development of the tidal Thames floodplains and the floodplains of the River Lea. Overall, the UK government continues to strongly focus development and regeneration in the London mega-city area, rather than to disperse more of it to other UK regions, in order to maintain and build up the competitiveness of London globally and within Europe. This is closely linked to the view that the south-east of England is closest to urban conurbations in Europe (the London-Paris-Brussels-Amsterdam-Frankfurt urban region) which is a particularly dynamic urban territorial region.

The UK does not yet have Building Regulations which mandatorily incorporate flood resistance and resilience measures which can reduce vulnerability to flooding, although it does for some other hazards such as windstorm, earthquake and soil heave/subsidence. As far as flooding is concerned, there is now considerable guidance available to planners, developers and builders on how to flood proof buildings, but these have not yet found their way into Building Regulations. The Environment Agency (2007, 2008) is seeking to promote these measures in the TE2100 flood risk management plan, and also to influence the pattern and form of spatial development through the Government’s Planning Policy Statement 25 (Development and Flood Risk) (DCLG, 2006).

One of the features of very large and large urban areas is the transformation of na-tech hazards in time and space. Distinctions between “natural” hazards and “technological” ones are becoming increasingly blurred, and it is at the same time increasingly difficult to separate these kinds of hazard from biological and social ones. This is particularly the case in urban settings where the sources of risk are multiple and where the experience is often of an interactive mix of hazards. So for example, severe weather and windstorms may shut down mass transportation systems owing to loss of power, in turn leading to crowd handling crises and other “spin-off” emergencies (Parker, 2003).

Wisner’s (2000) study of the black African township of Alexandra illuminates how a society following separation (i.e. apartheid) and resettlement policies led to the setting up of illegal shack communities or shanty-towns in which the spatial pattern of extremely dense urban settlement with insufficient services has led to critical hazard vulnerabilities (i.e. public health, fire, traffic hazard, waste dumping, air and water pollution, landslip and flooding hazards). The demographic and spatial instability of these non-white areas has made community assessment and mitigation of hazards more complex than for white areas, where there is also a widespread distrust of technicians who attempt to mitigate these hazards. Similar extremely dense and hazardous settlements are noted by Zoleta-Nantes (2000) and by Mahmud (2000) in The Philippines.

Remoteness or isolation within patterns of spatial development can lead to pronounced territorial vulnerability. In the context of the adequacy of tropical cyclone warning systems in the Republic of Mauritius, Parker (1999b) found that Mauritians living on the remote islands of the Republic such as Rodrigues, many hundreds of miles from Ile Maurice (the principal island), received an inferior tropical cyclone warning service making their territories more vulnerable to these violent storms. Even in Ile Maurice, fishermen who are economically marginalized and spatially separated when they are fishing at sea, also received an inferior warning service compared with those living on land.

1.5 Institutional and Territorial Vulnerability

1.5.1 Vulnerability to Floods

The following general comments by the Middlesex University team on the relationships between institutional inadequacies and territorial vulnerability to floods indicate how the former affect the latter and vice versa. While these comments have a specific reference to floods they are equally representative of the respective interplays in other hazard cases too. Nevertheless, it has to be admitted that on the whole institutional vulnerability remains an inadequately researched subject.

The adequacy of institutional arrangements (i.e. laws, organisational structures and responsibilities, administrative procedures and customs, and publicly held values and perceptions) for flood hazard reduction is constantly questioned, but particularly after severe flooding. Institution-building may be required where such institutions are currently poorly established and developed (as in the case of some developing nations) where the area of flood hazard reduction may be 'under-legislated' or there is 'institutional thinness'. Where institutions have already been 'thickened', constantly changing flood risk and/or social and economic requirements will lead to a constant search for the ideal institutional arrangements. The following are selected examples of interplays between institutional and territorial vulnerability.

Institutional inadequacies commonly exist in the linked areas of (a) public institutional responsibilities for flood hazard reduction, and (b) the sharing of responsibilities between the state and the citizen for preventing, reducing and adapting to flooding. Public institutional responsibilities for flooding may be split between various agencies which may not coordinate policies and plans successfully, and which may lead to ambiguous overall responsibility and leadership for flood mitigation. When members of the public see that state agencies take responsibility for building flood defences, they may assume or believe that all responsibility for flood reduction lies with the state, or should lie with the state. In these circumstances personal responsibility may be abrogated leading to an undesirable loss of a culture of self-protection. For example, where the state provides individual flood victims with financial compensation for flood damage, citizens are unlikely to take steps to obtain private flood insurance.

In summary, public perceptions about, and attitudes towards, flood hazard reduction can have pervasive influences upon individual and community vulnerability to flooding. These public perceptions and attitudes, and thus vulnerabilities, are often unique to particular territories. For example, in Scotland there is a widespread belief that government agencies should bear responsibility for preventing flooding and adapting to it, but in reality a high proportion of those experiencing flooding elect to protect themselves in various ways (Werrity et al., 2007). However, in northern Italian villages studied by De Marchi et al. (2007) in practice villagers widely delegate responses to flash flooding to the authorities, and their culture of self-protection has crumbled. In Saxony, where the state in the old GDR always used to provide hazards insurance, flood damage compensation paid by governmental agencies to individuals following the 2002 floods may have undermined personal acceptance of shared responsibilities for flood loss reduction (Steinfuhrer and Kuhlicke, 2007). In France, flood damage compensation rights are enshrined in the Constitution (Parker et al., 2008).

Inadequacies amongst flood emergency response institutions are frequently observed in post-flood emergency reports (e.g. lessons-learned reports or public

post-flood reviews). An example is the Pitt Review into the summer 2007 floods in England and Wales (Pitt, 2008), and the 1998 floods 'Bye Report' (Bye and Horner, 1998). Common findings of such reports in England have been that (a) the emergency services were ill-coordinated (b) information sharing between those responsible for ensuring flood resilience is insufficient (c) communications between them broke down (d) there was lack of clarity of lead agency roles – all leading to particular territorial vulnerabilities needing attention. The Netherlands is, for example, apparently more successfully organized in terms of emergency service response, particularly because the fire service has possessed the lead agency role for some time leading to clarity in this regard. However, the Netherlands has a different set of territorial vulnerabilities arising from flood emergency response institutions, particularly stemming from the very high standard of protection from flooding along the coasts and the complacency that this leads to amongst the public.

The concept of governance means different things to different people, but here we think of governance as the process of governing and also as the power and ability to bring about changed behaviour amongst citizens. Governance involves the interaction of formal institutions and those in civil society whereby power, authority and influence are wielded by some elements to change or maintain decisions concerning public life. Territories may be characterized by their unique forms of governance which will affect the vulnerability of territorial capital (including communities and people within them) to floods. In England, a recent research project for Defra, the Government department responsible for flood risk management policy, has examined social justice in respect to flood risk management and particularly in relation to decisions on allocations of funding for protecting communities at risk (Johnson et al., 2007).

One way of analyzing governance on flood vulnerability is to examine the system of social, financial and political incentives or disincentives (or 'policy signals') generated by a governmental system regarding reducing or reinforcing vulnerability. We see many such incentives and disincentives being present in particular systems of governance in Europe, and in the most problematic cases the weight of incentive/disincentive is in the direction of deepening flood vulnerability. A governance perspective is implicitly present in Wisner's (2000) study of flooding in Alexandra Township, in South Africa; and equally such a perspective might be used to develop a governance critique of changes necessary in New Orleans following the Hurricane Katrina disaster (Birch and Wachter, 2006).

The following paragraph 4.5.2 is devoted to a methodology for locating the availabilities and deficiencies of emergency response systems and emergency planning in case of a post-earthquake crisis in the Greek cities of Patras and Pyrgos. The methodology has been developed in the context of a relevant pilot Greek project.

1.5.2 Urban vulnerability and emergency planning in earthquake-prone regions: The pilot Greek project "Multidisciplinary investigation for antiseismic planning of cities on active faults"

(EPPO - Earthquake Planning and Protection Organisation of Greece and the European Union / DG XI / Civil Protection Unit, 1998)

During 1993, catastrophic earthquakes affected the Northwestern Peloponnese in Greece. They caused serious damage to the greater area of two densely populated cities, namely Pyrgos and Patras. These are the capital cities and the principal commercial centres of the neighbouring Prefectures of Ilia and Achaia.

Pyrgos city (administrative Region of Western Greece) is a medium-sized city that is characterized by high seismicity. Patras is the third city of the country in terms of population size and the capital of the Prefecture of Achaia and of the Region of Western Greece. It is the most important economic and administrative centres of Western Greece and Peloponnese. The city has experienced damaging earthquakes in the past with more recent the one that occurred in June 8th 2008.

After the disaster in 1993, Earthquake Planning and Protection Organisation (E.P.P.O.) and the European Union / DG XI / Civil Protection Unit, financed the pilot research project "Multidisciplinary investigation for antiseismic planning of cities on active faults" aiming at improving earthquake emergency and mitigation planning in the two cities. The project ran during the period 1995-1998 and comprised 7 studies including: (i) geological investigation and detailed geological mapping, (ii) neotectonic mapping, determination of faulting parameters and localization of the active tectonic structures, (iii) seismicity and seismic hazard investigation, (iv) geotechnical investigation, including a series of exploratory drillings and soil tests, (v) examination of the building vulnerability within the urban complex, and (vi) urban development study that focused on parameters pertaining to earthquake hazard and the post-disaster emergency phase.

The two projects focusing on the cities of Pyrgos and Patras paved the way towards improving emergency planning at the level of Municipality and better understanding the complementarity of mitigation and emergency planning.

The case of Pyrgos city (W. Peloponnese, Greece)

The project resulted in the compilation of an emergency operation plan which included segmentation of the town into distinct sectors, escape and emergency access routes, first aid stations and refuge camps.

Vulnerability of the buildings was estimated roughly on the basis of building types and age (Fig. 7). To evaluate accessibility (defined as the ease of access to a particular point after a disastrous earthquake) several weighted parameters were taken into account such as road width, height of adjacent buildings, geometry of roads (curves, dead ends), one or two-way streets etc.. Weighted parameters relevant to accessibility combined with building vulnerability give a first estimate of accessibility after seismic disasters. Figure 8 illustrates in three classes (bad, intermediate, good), the expected accessibility of Pyrgos city after a disastrous earthquake (design earthquake).

City zoning was considered essential for the implementation of emergency plans by the local and central authorities. Each of the 7 major sections of the city (Fig. 9) was further divided into 4 smaller sections. It was attempted to identify sections with similar area, building density, vulnerability and open spaces. Sub sections were established to facilitate operation management. The following emergency activities were considered as of prime significance in the emergency plan:

- Damage assessment
- Population evacuation, assembly and first aid.
- Extinguishing fires.
- Rescue and transportation to hospitals.
- Hospitalization - burial of dead.
- Clearing the roads (removal of obstacles and debris, demolition of dangerous elements).
- Provisions (food, water and clothing).

- Inspection of buildings and facilities.

A G.I.S. was developed with the aim to facilitate emergency action and decision making.

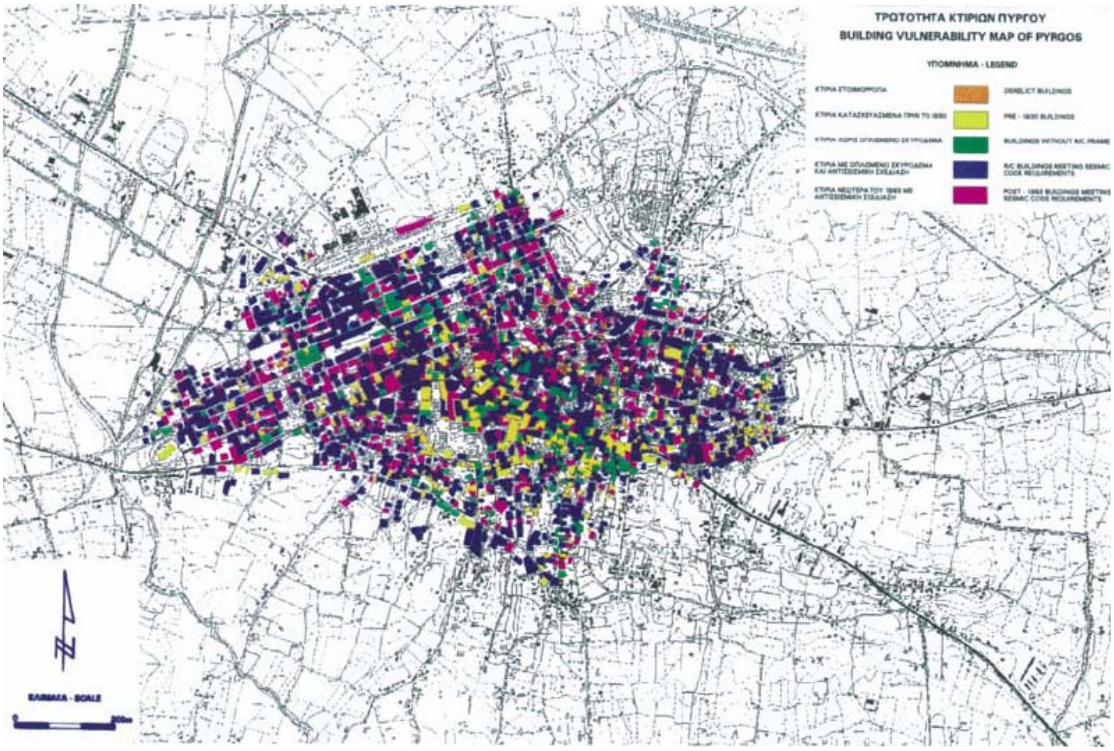


Figure 7: Building vulnerability in the city of Pyrgos *Sources: EPPO 1998, NKUA (National and Kapodistrian University of Athens) 1996.*

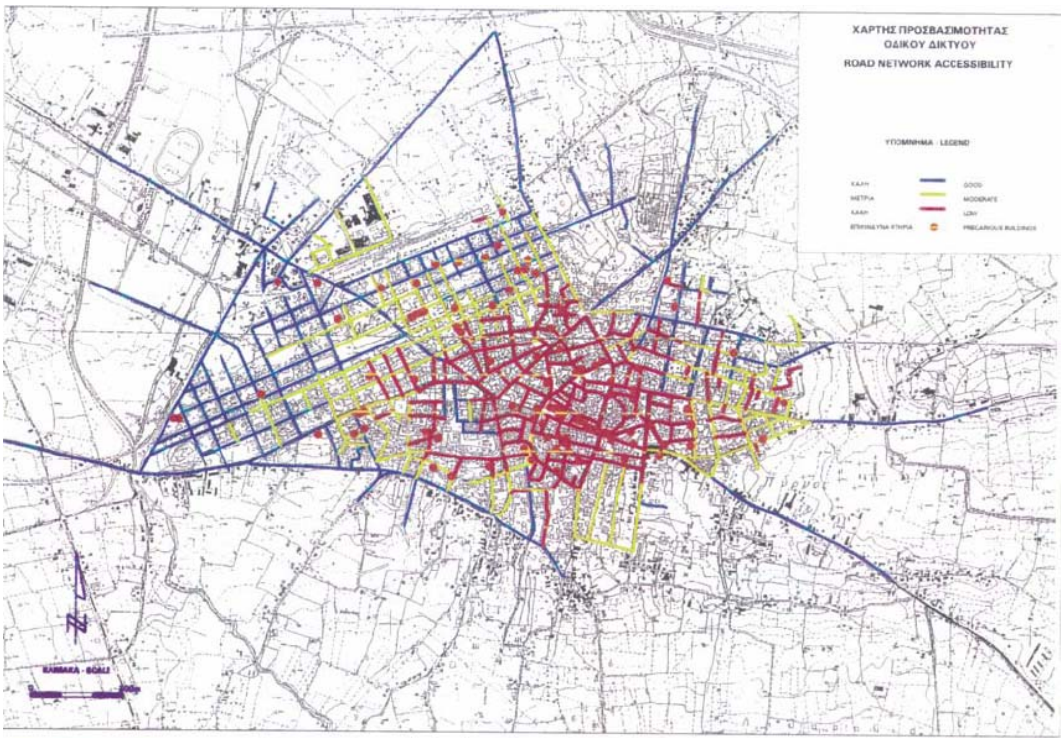


Figure 8. Accessibility of the road network of the city of Pyrgos after earthquake disaster. *Sources: EPPO 1998, National and Kapodistrian University of Athens 1996.*

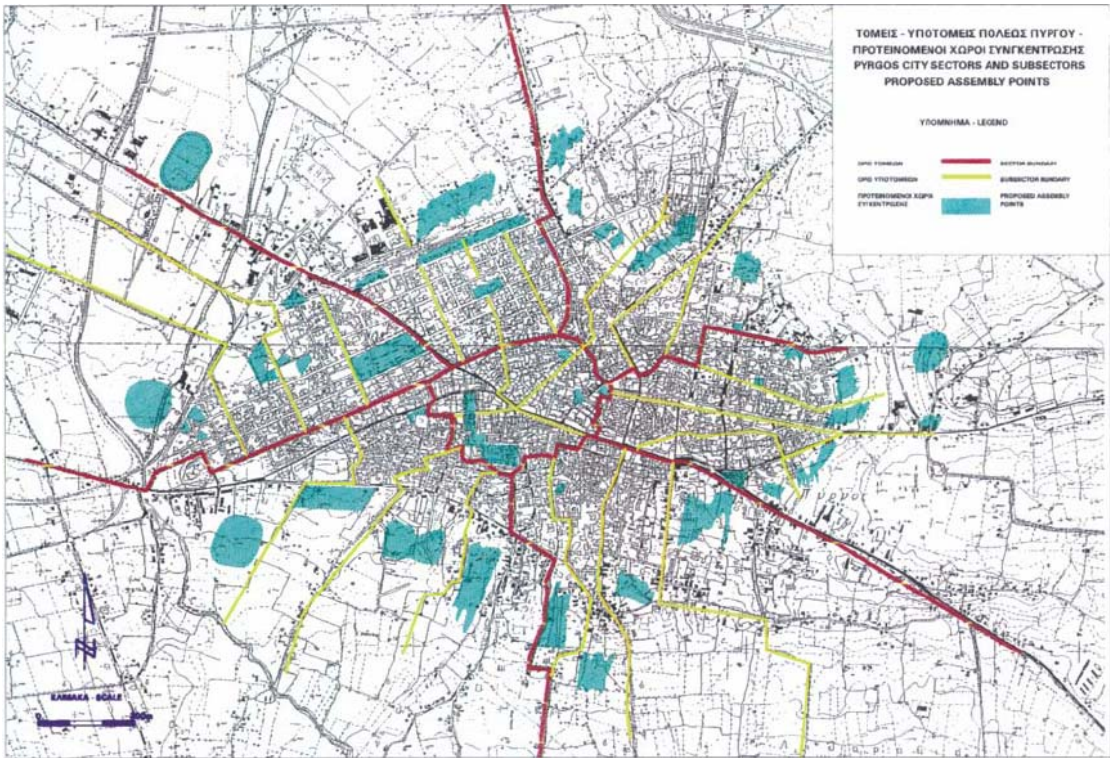


Figure 9. City sectors and proposed assembly points in the city of Pyrgos
Sources: EPPO 1998, NKUA (National and Kapodistrian University of Athens) 1996.

The project was intended to be an interdisciplinary one to target all aspects of emergency planning. Nonetheless, it is mainly focussed on geosciences and seismology leaving less room for earthquake engineering and almost ignoring urban planning and the socio-economic aspects.

Emergency planning was understood as a series of anticipated activities to be implemented efficiently after the disaster. It should be acknowledged that there has been an effort to include both spatial and organisational dimensions of emergency planning. Nonetheless the spatial dimensions are tackled through thematic mapping and are only loosely connected to the organisational ones; furthermore, the spatial - temporal dynamics of the emergency response and reconstruction have not been considered at all.

The only type of vulnerability that has been mentioned explicitly is structural vulnerability of buildings. The vulnerability of road network as well as vulnerability related to land use are merely implied as demonstrates the effort to assess negatively inadequacies and possible hindrances in these sectors during the emergency phase.

The case of Patras City: Organizational and urban planning aspects in the phase of emergency

The method in this case aimed at improving emergency planning for the city by taking into consideration administrative, organizational and spatial aspects in a balanced manner. A key issue was the appropriate integration of the Municipality of Patras into the emergency mechanism although at that time there was no

institutionalized role for the Greek Municipalities in the emergency management phase.

The analysis was GIS-based and comprised a wide spectrum of sectors:

- Hazard analysis and geotechnical considerations (Figure 10);
- Regional and urban planning including land uses, population distribution (Figure 10), building stock, open public spaces and transport network;
- Structural vulnerability;
- Institutional framework for emergency management and administration.

It followed a diagnosis of urban vulnerability and its geography across the city. The city was divided into 6 areas (Figure 11). The division rationale was based rather on the critical urban fabric features of each area and their implications in case of an earthquake than on estimations of the structural vulnerability of the building stock. Subsequently a prescription of key issues for emergency management was drawn for each area.

The final product of the study was a proposal of an emergency plan for the Municipality of Patras. The plan balanced spatial (Figures 12, 13 and 14) and organisational aspects setting up a framework of responsibilities for the Municipality and proposing its seamless integration into the overall response mechanism. Information on seismic hazard and vulnerability in the study area has been the background for emergency planning.

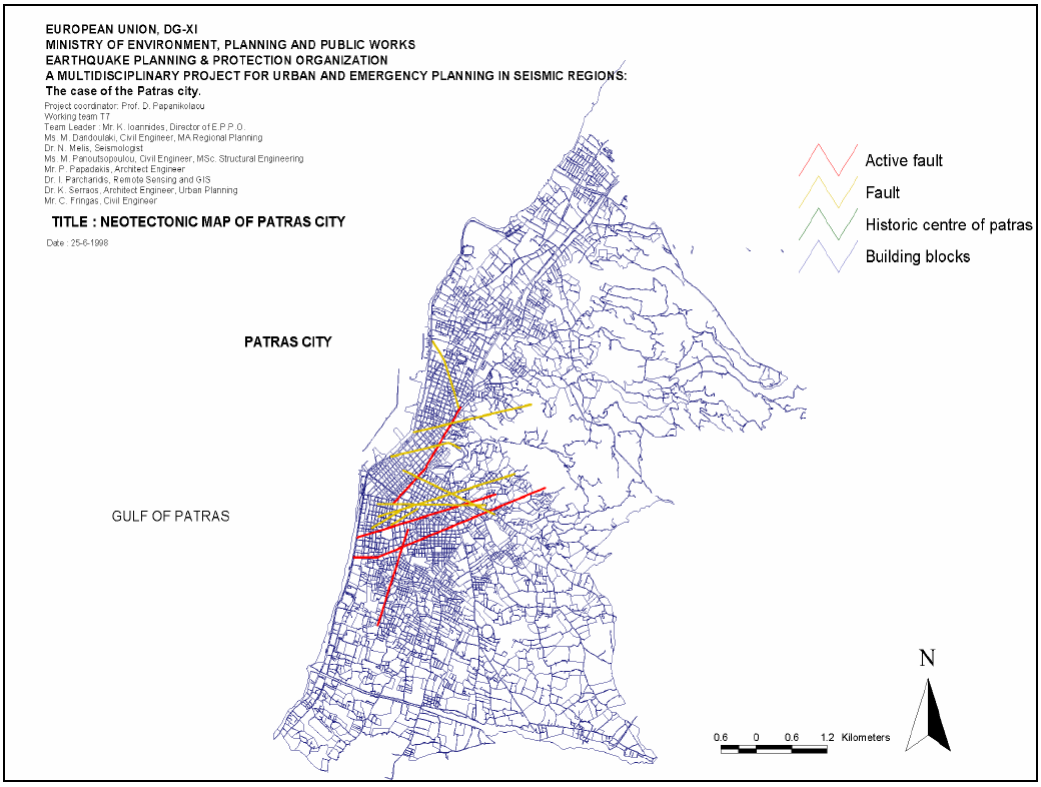


Figure 10. Seismic faults in Patras city, *Source: EPPO 1998.*

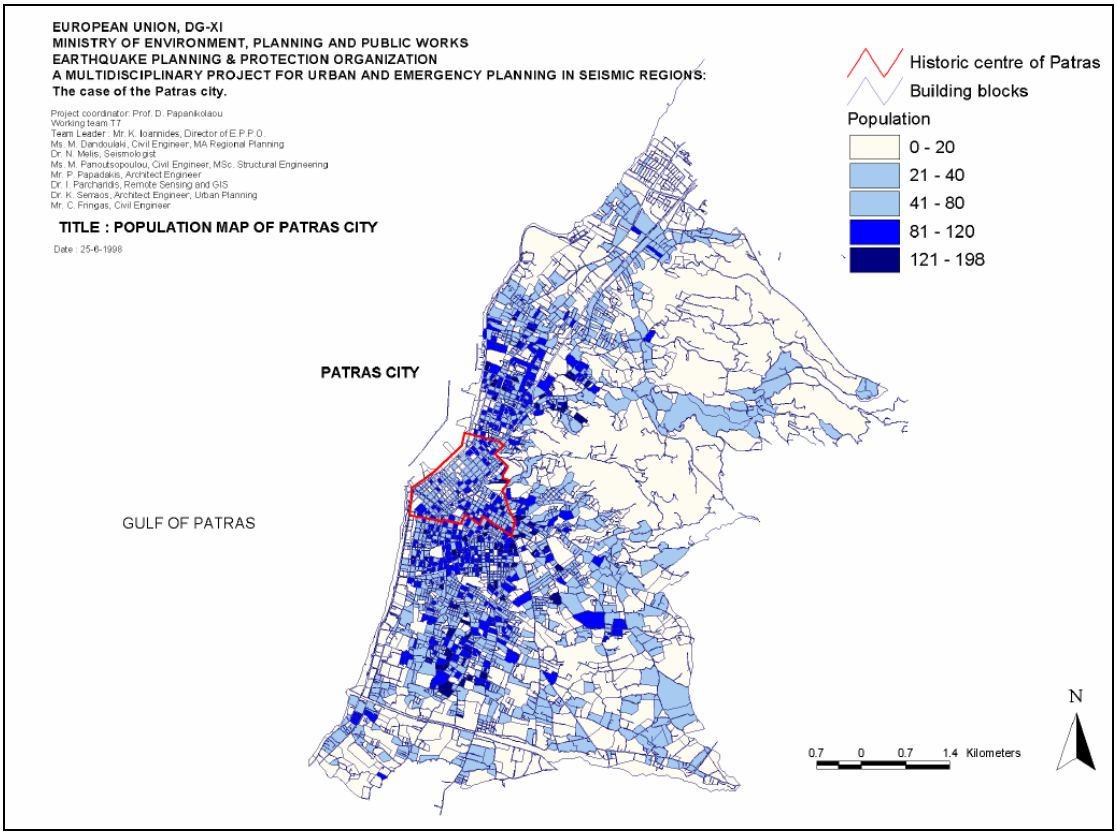


Figure 11. Population distribution in Patras city. *Source: EPPO 1998.*

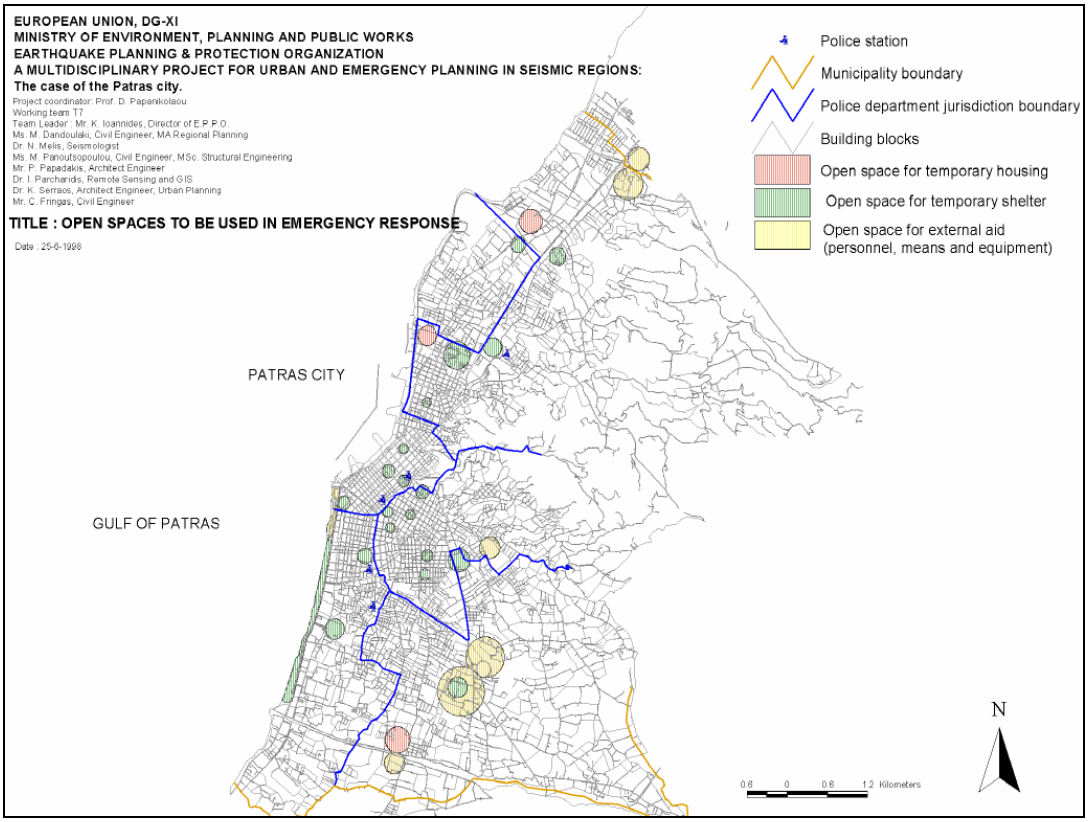


Figure 12. Emergency city sectors and proposed assembly points in Patras city. *Source: EPPO 1998.*

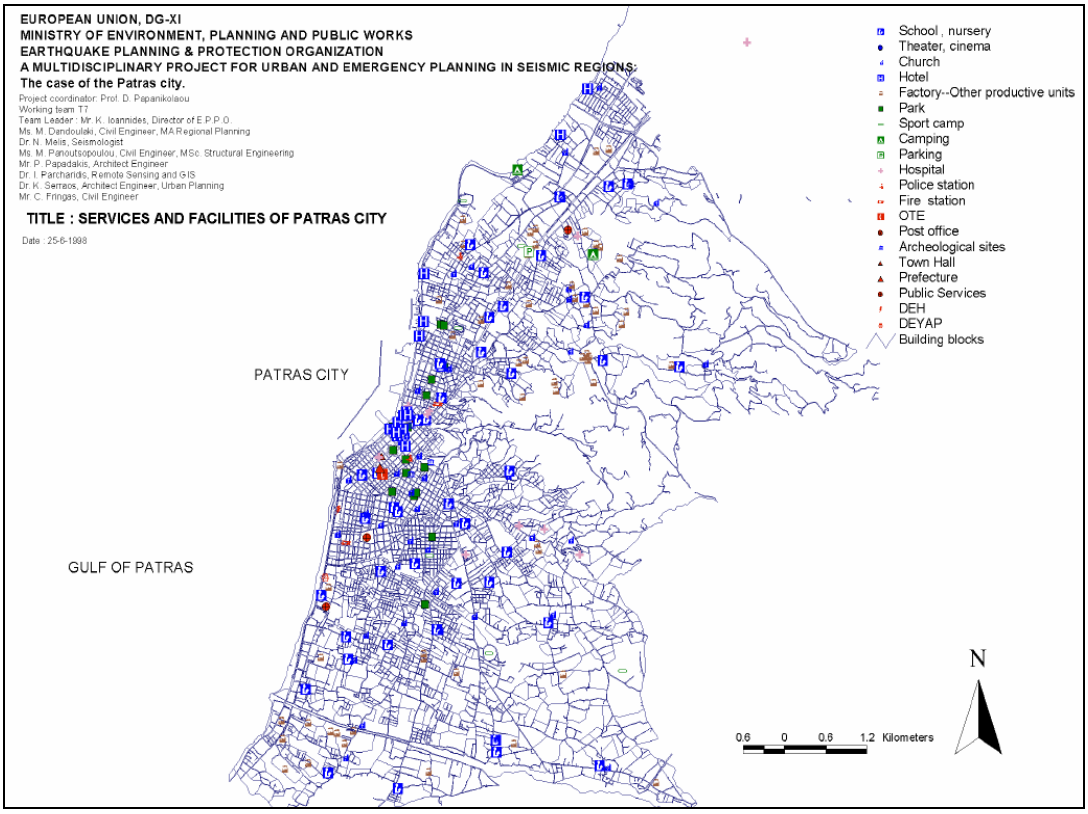


Figure 13. Critical and vulnerable facilities in Patras city. *Source: EPPO 1998.*

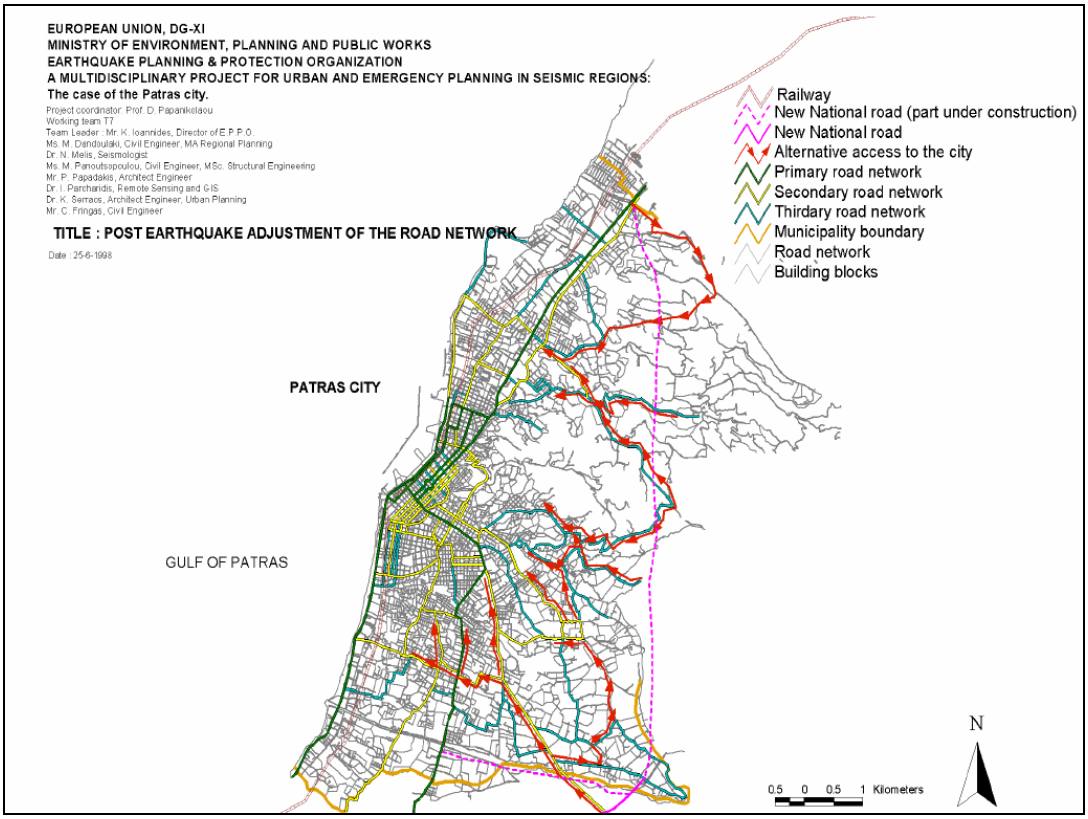


Figure 14. Post-earthquake adjustment of the road network. *Source: EPPO 1998.*

Although the Greek pilot project referred to the earthquake-stricken cities of Pyrgos and Patras, with an emphasis on the second case, it was expected to become (after the test of actual implementation) a basis for elaboration of integral emergency plans for other earthquake prone cities in Greece and Europe.

Indeed a series of studies of this type concerning other cities in Greece followed the examples of Pyrgos and Patras. However, in most of these studies the hazard part is dominant, while structural vulnerability is acknowledged as a crucial issue but its assessment is still at a primitive stage. There is no acknowledgement of any other type of vulnerability and the current tool of earthquake scenarios has not been used.

In the case of Patras accurate scientific information on hazard and structural vulnerability was not essential for emergency planning at this stage. A more qualitative approach produced a sufficient assessment of urban vulnerability based on regional and urban characteristics and also on experts' opinions. It is at a later stage that the information basis (hazard data, vulnerability data etc.) has to be more accurate for the refinement of the plan by means of earthquake scenarios. In any case, earthquake emergency planning is a continuous process interacting with ever-changing reality; therefore, in the view of the study team, proper updating of the plan is more essential than scientific precision of information at an initial phase.

The only way to keep an emergency plan alive is to promote it as a tool in the hands of the Municipality and part of its everyday activity. Only the Municipality itself could adjust, enrich and update the proposed plan step by step with the help of a constantly being updated Geographical Information System (GIS). Experience shows that this demands considerable effort.

The significance of regional and urban planning aspects in emergency planning is obvious. Increased consideration of these aspects can serve better connection between earthquake mitigation and emergency planning.

It should be stated that, although five different relevant studies have been carried out for the city of Patras, their use as a unified information base for earthquake planning proved to be impossible. This was due to the different reference scales but also to the fact that the scientific teams worked separately. With no constant collaboration in place, the separate scientific outcomes of the studies, although valuable, proved difficult to integrate in emergency planning. The project demonstrated that earthquake planning for medium and / or fairly large cities is more effective when considering both the dynamics of the urban area and the emergency mechanisms involved (in both spatial and organisational terms).

1.6 Interdependencies and Overlaps among Territorial and Systemic, Socio-economic, Physical Vulnerabilities.

1.6.1 The complexity of relationships between vulnerabilities

Socio-economic vulnerability is intimately related to territorial vulnerability because of the particular historico-cultural evolution of the social and political characteristics of territories (e.g. functional urban areas, sub-regions, regions). Hewitt (1997, 12) pointed to the uniqueness of territorial vulnerability when he referred to the 'geographicalness' of risks (i.e. hazards) and argued the importance of taking into

account the interrelationships and distinctive mix of conditions that define human settlements and regions.

In line with these observations, it is important to note that the basic message from the ESPON Hazards Project is that Territorial Vulnerability is the sum of economic, social and ecological vulnerability which in turn are determined by the exposure and coping capacity of the respective elements or entities. However, there are still many things missing in the ESPON approach: the space-time scales, structural and organizational issues, transformations and interactions between different forms of vulnerability. For instance, exposed economic elements are not only the physical, concrete elements which are damageable but economic structures as well such as firms or networks of production activities.

Of critical importance in the interacting web of vulnerabilities is institutional vulnerability, which is not adequately represented in this chapter. There are of course various references, e.g. to the weakness of organizational arrangements, but the complexity of institutional vulnerability was not on the whole analyzed in the approaches which we were in a position to present.

1.6.2 The case of floods

Taking as example the case of flood hazard, two empirical studies from the literature demonstrate the importance of the 'territorial experience', although there are many other similar case studies (e.g. see Mitchell, 1999). Firstly, Parker and Tapsell (1997) demonstrate how, through longevity, London – the oldest of contemporary megacities – has developed a unique perspective on urban hazards with low recurrence intervals because there have been correspondingly more opportunities for social learning about ways of adjusting exposures and vulnerabilities to such hazards through adoption of particular institutional and policy responses. Secondly, in the context of a dynamic newly-industrialising economy, Chan (1995) reveals how the socio-economic vulnerability of Peninsular Malaysian society is heavily differentiated by the variegated ethnic mix. In this society where economic vulnerability may be measured by income level, the low income, predominantly rural, Bumiputeras (i.e. the indigenous Malays) might be expected to display the highest levels of vulnerability to floods. However, their vernacular 'kampung' house architecture is well adjusted to flooding, and their territorial social capital which includes their strong kinship bonds, make them less vulnerable to flooding than more mobile, higher income Chinese and Indian groups living in less well adapted flood prone urban settings.

Systemic vulnerability refers to physical, economic and social systems which are functionally connected at different levels of functioning such as the local/urban and regional systems. Connections may work laterally (i.e. between neighbouring regions) as well as vertically (i.e. between sub-regions and the region, or between regions and the nation). The initial effects of flooding, whether they be physical, social or economic can propagate from one system to another and from one level or region to another so that the initial impact is spread, and increased or magnified. The impacts of hurricane Katrina on New Orleans in 2005 are a powerful illustration of the systemic vulnerabilities propagated by physical and economic vulnerabilities and the differential fragilities of businesses. The economic impacts in New Orleans, including the collapse in municipal tax revenues, business bankruptcies, the disruption of utilities, the delay of exports by the closure of the port, and the property damage, spread to the State and on to the federal level temporarily increasing energy prices, reducing annual economic growth by up to 1%, and seriously affecting the global insurance/re-insurance industry.

Against this, construction materials markets and businesses saw gains in the reconstruction phase. Some companies and public agencies with business continuity plans in place fared much better than those without, but generally SMEs may often be particularly susceptible to loss and bankruptcy. Large companies which had made contingency plans to transfer staff to pre-planned accommodation in another state avoided much loss and disruption. The loss of over 1,800 lives, long-term evacuations of families, loss of communities, business bankruptcies, the problems people encountered in dealings with insurance companies and ill-health caused by the event and its aftermath, are just some of the surface indicators of human suffering and social impacts (Birch and Wachter, 2006). Similar systemic vulnerabilities are identified in detail in case studies of other floods in the US, including the Mississippi floods of 1993 (Changnon, 1996) and 1927 (Barry, 1997). Barry's account demonstrates the far-reaching systemic economic, social and political vulnerabilities which a major flood disaster can reveal.

At the national level economic parameters have been used to formulate macro-economic indices for identifying particularly vulnerable territories (Lewis, 1999; Cherveriat, 2000). The UN Development Policy and Analysis Division uses an Economic Vulnerability Index (EVI) which includes seven parameters including remoteness (i.e. peripherality), merchandise export concentration, instability of agricultural production, and homelessness due to natural disasters. Briguglio (1992, 1997) provides examples of parameters used in economic vulnerability indices.

1.6.3 Conclusions from the Approach to Seismic Vulnerability of Small Manufacturing Firms in Western Athens

The first lesson learned from the approach is that territorial vulnerability contains, and is a synthesis of, all forms of vulnerability, i.e. physical, socio-economic and systemic. Territorial vulnerability is a condition created before the disaster event and undergoes internal changes rapidly after the manifestation of a hazard via redistribution processes. The latter are activated by public institutions but also by private agencies and individual social domains. A catalytic factor to this activation is resilience.

The second lesson is that physical exposure and physical resistance are responsible for damages and impacts (direct and indirect) while social resistance and resilience are activated after the manifestation of disaster. Together they constitute the capacities of social domains (micro-and macro-) to cope with impacts and losses.

Exposure of macro- and micro-structures and territorial units is generated basically by governmental policies and institutions; the individual entities and social domains have limited capabilities to avoid or mitigate exposure, especially those at the lower end of the socio-economic ladder.

Resistance is much more an issue of individualized growth and development of the agency / domain under stress. The resistance potential is activated on individual basis and it decreases vulnerability without transferring it to others. The social domains at the lower socio-economic positions are featured by low resistance potential (due to their smallness and limited assets and availabilities). Resilience is also an individualized mode of coping with losses and catastrophes and thrives in contexts where public policies and interventions are weak and ineffective. While resistance can be boosted by appropriate public policies, resilience is the only

possibility of survival of deprived agencies in an environment of free and tough competition for vulnerability relief. However, resilience is a mechanism of own vulnerability relief by transferring vulnerability burden to others.

In conclusion territorial vulnerability is a function of (a) the physical exposure of the numerous socio-spatial domains (or micro-territorial units) of an urban structure, (b) the exposure of the material or immaterial systemic interconnections between these units, (c) the resistance and resilience potential of the socio-economic component of the above units, (d) the additional exposure element that is received by the above units due to activation of the resilience potential of all surrounding or interconnected units. It is questionable whether above factors can be co-assessed, they have different content and locus of reference and they emerge, accumulate and activate at different phases of the disaster cycle.

1.7 General Conclusions

1.7.1 Approaches to Territorial Vulnerability: Advancements and future challenges

After the brief review of the most recent approaches to territorial vulnerability it is worth referring to the similarities and differences among them as well as their achievements on one hand and insufficiencies on the other:

1. To the scientific and research communities of Hydro-Geological Risks/Hazards on the one hand and Climate Change on the other, the meaning of Territorial Vulnerability reflects propensity to losses of complex geographical entities (to the Climate Change community this propensity includes the generation of exposures and new hazards by these entities) due to a stressor. These complex entities incorporate physical, social, economic, cultural, organizational, institutional micro-units and macro-structures. Territorial vulnerability denotes susceptibility to losses of all above 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 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.

2. According to the above various conceptual interpretations exist different procedures of assessment of territorial vulnerability. Some methodologies start from consideration of vulnerability of the micro-units included in a territory (without ignoring the influence of the wider structures) and proceed then step by step to larger and larger scale units. Other methodologies follow the reverse path; these start from macro-structures and macro-indicators and attempt subsequently indicator specializations and division of the territory to lower scale units.

3. 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; they deal instead with the end results, the observable symptoms of vulnerability. They elaborate quantitative and space variable parameters and manage to arrive at mapping results showing the spatial distribution of vulnerability at various scales. In the few cases of approaches and models searching for the mechanisms of vulnerability generation, expansion and transference, no rating of locations / spatial units according to their vulnerability level or mapping results have been achieved.

4. Some of the approaches are hazard specific (such as the cases of approaches to vulnerability to floods, the CIPE-MURST methodology and the methodology referring to seismic vulnerability of micro-territories in Athens); others refer to groups of hazards (such as the Munich Re and DRI approaches) and a third group of methodologies are hazard-independent or applicable to all hazard cases (e.g. ESPON Hazard methodology, ARMONIA etc). The researchers dealing with single hazard situations consider the determination of vulnerability to multi-hazards as the major challenge of the future. On the contrary, researchers pre-occupied with the general aspects of vulnerability applicable to all hazard cases presume hazard-specific vulnerability as the major issue of the future.

5. While most approaches acknowledge that vulnerability of spatial units is multidimensional as it incorporates social, economic, functional, systemic and physical aspects, this rule is not followed in most of the specific methodologies. Often, although claims are made that multiple aspects of vulnerability are taken into account, the end-result is almost exclusively "physically-oriented" and dependent on land-use parameters, for practical reasons. Some approaches are concerned with social and economic indicators alone (DRI and ESPON), some are pre-occupied with building damages (Munich Re approach) and others focus exclusively on functional and systemic vulnerability (e.g. CIPE-MURST methodology and the methodology for the Italian historic city-centres). In other words each individual approach is not but a partial view of the problem of vulnerability. When for instance "coping capacity" of a district is estimated in terms of availability of emergency equipment and road accessibility indices alone, other aspects (physical, social, economic) are missing (e.g. personal and household mobility issues, education and training aspects, accessible economic and social assets etc.). This means that trade-offs between the several aspects of vulnerability and resilience are not captured. An indicative example is the case of a hospital or a productive firm that activates an emergency electric generator when electricity supply is interrupted due to damages in the electricity distribution network. In practical terms, physical vulnerability may be traded off by organizational resilience and the result as regards overall response may surpass the expectations inferred by estimations of physical vulnerability alone.

6. The relationship between exposure and vulnerability is proved to be the most intricate and disputable issue. At one end we have the DRI methodology considering exposure as an independent, exogenous factor, out of and irrelevant to the intrinsic and endogenous property of vulnerability. At the other end the ESPON Hazards methodology identifies exposure with the damage potential component of vulnerability, where the aggregate of this potential and the coping capacity represents the respective vulnerability level. In between the two extreme cases other methodologies (such as ARMONIA and the methodology for mudflows by DIPISTO) avoid mathematical operations to extract composite vulnerability indices. These latter methodologies acknowledge that exposure and coping capacity often have completely different locus and scale of reference and

different periods or moments of occurrence. For instance, population's exposure within a neighbourhood unit might be estimated on the basis of population size and density parameters at the neighbourhood level but coping capacity of the area and its population may depend on road network accessibility at entry points far away from the spatial unit under consideration. Besides, urban factors that aggravate exposure might enhance coping capacity or the other way around. Furthermore, initial exposure in the event of actual disaster may alter the urban landscape (and not alone) in unpredictable ways that undermine the assumptions made for coping capacities in normal periods and hence estimations and projections of the overall vulnerability potential.

7. As mentioned, 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. In a way the methodologies have been built to serve the need for maps that depict spatial distribution of vulnerability to support spatially differentiated measures and policies. However, this rationale presupposes that vulnerability fluctuates solely in terms of space, which is not the case. The immaterial aspects of vulnerability, e.g. institutional vulnerability, are certainly not mappable and these immaterial aspects might affect the material ones or be affected by them. These interchanges are lost altogether by the "snapshots" of single faces of vulnerability. Therefore the efforts to arrive at results that can be represented on maps lead to dangerous simplifications that neutralize the dynamic and non-spatial properties of vulnerability. As we emphasized earlier it is the absence of adequate coverage of institutional vulnerability which is particularly to be deplored.

8. The sociologists' point of view that vulnerability is the composite result of exposure, resistance and resilience (Kasperson et al. 1996; Pelling 2003) is very close to the perception of vulnerability by the Climate Change Community as a synthesis of exposure, sensitivity and adaptive capacity. On the other hand when vulnerability is taken as the product of exposure and coping capacity the latter component is not clearly defined. Does it concern pro-active counter-disaster properties alone? Does it refer exclusively to post-disaster remedies and rehabilitation action or both of the above? Some researchers would like coping capacity to encompass both pre- and post-disaster ability for action; however co-assessment is problematic since it necessitates time compression and equalization of diverse and distant agencies / domains (for instance the population groups living in a district may be exposed to specific hazards to which they respond with their own coping capacity; at the same time they are dependent on the coping capacity of the institutions that assume the emergency operations should a crisis come up).

9. The methodologies differ in terms of their stance as regards the type(s) of losses to which vulnerability refers. In some cases the referred type of loss is explicitly quoted (for instance in the case of DRI); in others it is implicitly derived (e.g. in the case of manufacturing firms in Athens where survival / continuity / closure is at stake); 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). Indeed, once the losses under consideration are not stated one is allowed, if not encouraged, to include everything. The underlying assumption is that if capacities and strengths are missing anything can happen; the type of

impact is irrelevant to vulnerability. However, this is debatable. For instance, dismissals of firms' employees might result or might not result from structural vulnerability of the premises housing the firms; on the other hand it might be the outcome of medium term secondary impacts such as business interruption for a couple of weeks due to lifeline failures or even due to decrease of the annual turnover of the firm as a consequence of disturbances to the wider economic activity in the urban area destroyed. Hence, vulnerability to physical damages and direct loss of immovable assets is something completely different from vulnerability to long term impacts and incapability of survival in the long run. Besides this latter, long term vulnerability is an undesirable property that one can get rid off because it can be externalized to other interconnected agencies. Long term vulnerability is an unwelcome evil that may be easily removed.

10. As already mentioned in most methodologies vulnerability is not assessed as a time variant parameter. It is approached either as an instantaneous property of a spatial entity (e.g. the Munich Re approach at Mega city scale considering vulnerability at a distinct moment) or as if vulnerability repercussions that extend actually over long periods could be piled up at a specific post-disaster moment (e.g. the points of view of DRI and ESPON Hazards project). Time compression here is a problem because needs, capacities and action at the emergency and recovery periods are consequential to first instance, direct losses after the disaster and they cannot be anticipated before disasters but only as probabilities dependent on prior stage eventualities. However, in the real disaster conditions first instant losses (due to pre-disaster vulnerabilities) are 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.

11. In most approaches, the fact is neglected that vulnerability is closely connected to a locus of reference, i.e. the agency or the system carrying it; in some cases this agency / system is capable of self-regulation and adaptation through learning in some other cases it is not. Anyhow the various agencies in the context of territories interact and some succeed in "unloading" their vulnerabilities (either consciously or unconsciously) to the disadvantage of others. Hence, aggregation of vulnerabilities of the components of a territorial unit (or the subsystems of a system) does not reflect its overall vulnerability. Socio-economic and physical vulnerabilities are not properties of the same entity; they are not independent quantities measurable on the basis of a common measure that can be added up to reflect the vulnerability of a totality.

12. It has been obvious from the above that mapping vulnerability values raises questions. Maps are representations of parameters that are spatially determined and more or less settled and steady in temporal terms. However, vulnerability is nothing of the sort at least in post-disaster periods; it has to do with dynamic action and movement and undergoes changes from month to month even from one day to another. Surely pre-disaster exposure (in some respects a basic component of vulnerability) is a mappable condition though exposure in our days has become a rapidly changing situation too; but resilience (if we consider it as another component of vulnerability) has to do with inventiveness, it comes up as a product of human knowledge, intuitiveness, innovation, cleverness; it is the creature of the moment. Resilience is a matter of immaterial assets and intimately connected with organizational issues and in this sense it is a non-spatial property therefore non-mappable.

13. Finally, our review of approaches to territorial vulnerability has shown that they are not only by and large limited, but also that there is a lack of adequate links with the wider study of territoriality and territorial structures, as a separate spatial concern and field of analysis. At this point therefore it is essential to return back to the introduction of the chapter and initiate a deliberation on possible relationships between territorial vulnerability and territorial capital. We do not claim of course that what follows is derived as a conclusion from our review of territorial vulnerability research, policy making and methodologies.

1.7.2 Territorial Vulnerability and territorial capital

In the introduction and in the section on objectives we introduced the concept of territorial capital and we stated our intention to explore its potential use in the analysis of territorial vulnerability. We shall present here very briefly the relevant (and very limited so far) literature on territorial capital. We consider this of great interest for the study of territorial vulnerability. Although the writings on territorial capital consider it as a concept which is useful for the study of regional development, we are of the view that the territorial capital of an area is a critical factor for determining territorial vulnerability as well. The concept of territorial capital is a novel introduction into the "territorial" literature. In the few contributions to the subject the claim is made that it was first introduced in a 2001 OECD publication, which we mentioned already, but the first reference to it, to the best of our knowledge, can be found in a paper by Josef Konvitz, who claims that "the economic future [of nations and regions] is shaped in part by how well territories can exploit and enhance their endowments and assets, what can be called *territorial capital* " (Konvitz 2000, 657) (Italics added).

In the introduction we quoted a frequently mentioned paragraph from OECD's report *Territorial Outlook* of 2001. We draw attention to the fact that in the definition of territorial capital included there we find a reference to both tangible and intangible factors, including e.g. customs, informal rules, solidarity and other concepts of great relevance for territorial vulnerability.

Important references to territorial capital can be found later in European Commission documents. In the EU *Third Report on Economic and Social Cohesion* of 2004 the term is not being used and there is only indirect reference to it, but there is reference to territorial cohesion: "The concept of territorial cohesion extends beyond the notion of economic and social cohesion by both adding to this and reinforcing it. In policy terms, the objective is to help achieve a more balanced development by reducing existing disparities, preventing territorial imbalances and by making both sectoral policies which have a spatial impact and regional policy more coherent. The concern is also to improve territorial integration and encourage cooperation between regions" (CEC 2004, 53).

Direct references to the concept of territorial capital are included in a series of documents drafted in the process of preparation of a policy document on the Territorial State and Perspectives of the European Union which ultimately led to the "Territorial Agenda of the European Union", agreed at an Informal Ministerial Meeting in Leipzig in May 2007. In discussing the reasons of a territorial approach to development, the authors of a 2005 Scoping Document insist that "each region has a specific territorial capital that is distinct from that of other areas and generates a higher return for certain kinds of investments than for others, since these are better suited to the area and use its assets and potential more effectively. Many of the components of territorial capital, including their integration and connectivity to other areas, can lead to productivity gains and generate growth" (EU Informal Ministerial

Meeting 2005, 3). A definition of territorial capital is also provided in a short 2008 document of the Assembly of European Regions: "Territorial capital: What makes an area distinct from the others in terms of development potential. It is determined by a wide range of factors, such as geographical characteristics, size, climate, history … This territorial capital gives a region some strengths and weaknesses, generally called 'development potential' or 'structural difficulties'. The aim of a balanced territorial development is to give each region the opportunity to make the best out of its territorial capital" (Assembly of European Regions, 2008a). From a slightly different perspective, reminiscent of the OECD definition, Skjerpen considers that territorial capital is determined by "geographical location (size, production endowment, climate, agglomeration economies etc.), untraded interdependencies (understandings, customs, informal rules, mutual assistance, social capital) and intangible factors (institutions, rules, practices, research and policy-makers that make a certain creativity or innovation possible)" (Skjerpen 2008).

The importance of a territorial approach as an integrating framework of policy-making is stressed repeatedly in European Commission reports and territorial development policies are in fact viewed as "an important instrument for strengthening regional territorial capital" (EU Editorial Group 2006, p. 3). A document issued by the EU German Presidency of 2007 and entitled *The Territorial State and Perspectives of the European Union* formed the basis for the Territorial Agenda of the EU, which was eventually agreed in Leipzig in May 2007. Here we find, once again, both the OECD positions regarding territorial capital and the arguments outlined in previous EU preparatory documents. It is interesting that in this document there is reference to some of the components of territorial capital, i.e. to resources (economic and non-economic, social, environmental, cultural, and the '*genius loci*'), as well as to integration and connectivity (German Presidency 2007, p. 5).

In Lisbon, in October 2007, the heads of government of the EU Member States approved the final text of the EU Reform Treaty. In it, the aim of territorial cohesion is placed alongside the already established goals of economic and social cohesion. The European Commission is due to produce a Green Paper on Territorial Cohesion, which is expected to be released very soon. In a discussion document of the Assembly of European Regions (2008) it is stated that "territorial cohesion means exploiting as much as possible the so-called 'territorial capital' of a given geographical area" and that it should "enable territories to identify and take advantage of their territorial capital" (Assembly of European Regions, 2008b). It must be noted that, as Peter Schön remarks, the notion of territorial capital had been already implicitly referred to in article III-116 of the EU Amsterdam Treaty of 1997 (Schön 2005, 394).

Following the attempts to define territorial capital in OECD and EU documents and reports, the concept was addressed in the final report of the ESPON project 2.3.2 in 2006, already mentioned in our introduction. The following extract is taken from the section "Territory as territorial capital: territorial governance as territorialized collective action" of the report:

> "The concept of territorial capital … is a relational and functional concept at the same time … whose elements are different but with common characteristics …
>
> - they are a localised set of common goods, producing non divisible collective assets that cannot be privately owned;
> - they are immovable goods, that is constantly part of specific places;
> - they are place-specific, that is almost impossible to find elsewhere with the same features;

- they are heritage goods, that is they are stocked and sediment in a long period and cannot be produced easily in a short time.

Factors that compose territorial capital are, for instance, geographical location, the size of the region, natural resources, quality of life, local and regional traditions, mutual trust and informal rules, etc. These factors can be grouped as:

- natural features;
- material and immaterial heritage;
- fixed assets … as infrastructures and facilities;
- relational goods … as cognitive, social, cultural and institutional capital …

Synthesizing, the notion of territorial capital allows to sum up the different forms of capital (intellectual, social, political and material capital) …" (ESPON project 2.3.2, 2006).

These views were reiterated by Governa and Santangelo (2006) and then by Davoudi, Evans, Governa and Santangelo (2008), where the point is made in addition that "applied particularly to the local or regional level the concept of territorial capital is similar to that of 'endogenous potential'". Camagni (2005) discussed the components of territorial capital (see introduction) and later provided the most comprehensive analysis of the concept of territorial capital which has come to our attention (Camagni 2007).

Camagni explored the concept of territorial capital through a taxonomic processs by placing it in a 3 by 3 matrix, along a vertical axis labelled "rivalry" and a horizontal one labelled "materiality", as shown below. The three rivalry categories refer to the private – public continuum of goods, while the three materiality categories refer to the tangible – intangible continuum (Fig. 15).

In Camagni's view, "the four extreme classes – high and low rivalry, tangible and intangible goods – represent by and large the classes of sources of territorial capital usually cited by regional policy schemes. They can be called the 'traditional square'". In the above figure, they are marked by trellis shading and by the letters c, f, a and d. "On the other hand", continues Camagni, "the four intermediate classes represent more interesting and innovative elements on which new attention should be focused; they can be called the 'innovative cross'" (Camagni 2007, 5). They are marked in the above firure by solid grey shading and by the letters i, b, e, g and h. The components of territorial capital included in the shaded squares are extensively explained by Camagni and can be compared with the elements of vulnerability identified in the relevant vulnerability literature, e.g. in the analysis of Wisner *et al*. (2004). Camagni concludes that "territorial capital is a new and fruitful concept which enables direct consideration to be made of a wide variety of territorial assets, both tangible and intangible, and or a private, public or mixed nature. These assets may be physically produced (public and private goods), supplied by history or God (cultural and natural resources, both implying maintenance and control costs), intentionally produced despite their immaterial nature (coordination or governance networks) or unintentionally produced by social interaction undertaken for goals wider than direct production" (Camagni 2007, 13).

Rivalry			
Private goods (high rivalry)	c	i	f
Club goods and impure public goods	b	h	e
Public goods (low rivalry)	a	g	d
	Tangible goods (hard)	Mixed goods (hard + soft)	Intangible goods (soft)
	Materiality		

Figure 15: Sources of territorial capital according to Camagni (2007)

There is a clear cross-fertilization between a number of scientific fields concerned with vulnerability, territorial development and poverty, to name but a few. This is in fact acknowledged as far as vulnerability, livelihood and poverty are concerned by Wisner, Blaikie, Cannon and Davis (2004, 95), in a section in which they explain the changes made in their book in comparison to its previous 1994 edition[4]. The definition of vulnerability given by Wisner *et al*. has been quoted in our introduction.

Wisner *et al*. put forward an analytical model which is illustrated in a diagram. The diagram includes a presentation of "the progression of vulnerability" from "root causes", to "dynamic pressures" and then to "unsafe conditions" (op.cit., 51). In a second diagram they present "the progression of safety" through successive actions called "address root causes", then "reduce pressures" and, finally, "achieve safe conditions" (op.cit., 344). As we show later, we have retained the parameters used under the heading "the progression of vulnerability" and produced a table in which we attempt a comparison with Camagni's components of territorial capital. Worth mentioning is that Wisner *et al*. also discuss the notion of livelihood. Although this is a subject which we are not touching here, we note that in their view "livelihood analysis seeks to explain how a person obtains a livelihood by drawing upon and combining five types of 'capital'", which the authors consider similar to the assets that are involved in one of their vulnerability models:

1. Human capital (skills, knowledge, health and energy);
2. Social capital (networks, groups, institutions);
3. Physical capital (infrastructure, technology and equipment);
4. Financial capital (savings, credit);
5. Natural capital (natural resources, land, water, fauna and flora)" (Wisner *et al*. 2004, 96).

[4] Blaikie, P., Cannon, T., Davis, I. and Wisner, B. (1994), *At Risk: Natural Hazards, People's Vulnerability and Disasters*, Routledge, London.

Once again, if we look at the parameters listed in brackets we find a clear and most interesting similarity with the components of territorial capital. What emerges from our review of the literature is that there are interesting (and promising) bridges between concepts and the literature which has dealt with them, in spite of the diverse origins and initial premises. E.g. we speak of "economic, social and territorial" cohesion and / or capital and we do the same thing with respect to vulnerability, although the "territorial" attribute of the latter has not so far been explored and researched, except in a narrow material sense related to buildings, solid infrastructures and land uses, i.e. elements that can be mapped and recorded in Geographical Information Systems[5]. As we pointed out in the introduction there is a missing link between vulnerability and territory, which is underlined in the writings of Susan Cutter:

> "Vulnerability science requires an integrative approach to explain the complex interactions among social, natural and engineered systems. It requires a new way of viewing the world, one that integrates perspectives from the sciences, social sciences, and humanities. Since vulnerability can refer to individuals (person, housing structure), groups, systems, or places, scalar differences and the ability to articulate between geographic scales are important components. Vulnerability manifests itself geographically in the form of hazardous places (floodplains, remnant waste sites); thus, spatial solutions are required, especially when comparing the relative levels of vulnerability between places or between different groups of people who live or work in those places" (Cutter 2003, 6).

Territorial vulnerability (but also vulnerability in general) and territorial capital (but also other types of "capital") share a common characteristic: they are multidimensional and complex concepts. As to territorial capital, we have repeatedly seen, especially in Roberto Camagni's analysis, its multidimensional character. Both territorial vulnerability and territorial capital essentially describe an areal 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. If we view them in this perspective we can easily see the potential of bringing these concepts closer together in order to better understand vulnerability. Territorial capital analysis can offer a tool for explaining the workings of vulnerability, although it is certainly not the only one.

The literature on vulnerability is full of references to the elements of vulnerability of communities and to make a comprehensive list is in itself a major task. However, we can take the features which Wisner *et al*. have listed under "the progression of vulnerability", to which we have referred already, and use them as an adequate list which we can compare to the elements of territorial capital. For the latter we can use Camagni's matrix. We should not forget of course that he uses the concept of territorial capital for a totally different purpose, i.e. to determine the development

[5] See e.g. the papers presented by a research team of the Politecnico di Milano, derived from the European research project QUATER (Treu, M.C., A. Colucci and S. Lodrini, Territorial vulnerability analysis: The methodological framework, in C.A. Brebbia, ed., *Risk Analysis IV*, WIT Press, 2004; Treu, M.C, M. Samakovlija and M. Magoni, Territorial vulnerability analysis: The case studies, in C.A. Brebbia, ed., *Risk Analysis IV*, WIT Press, 2004; Baldi, C., M. Martelli and M.C. Treu, Territorial vulnerability analysis: The Environmental Risk Managemens Systems, in C.A. Brebbia, ed., *Risk Analysis IV*, WIT Press, 2004; Treu, M.C, A. Colucci and M. Samakovlija, Territorial vulnerability and local risks, in *WIT Transactions on Ecology and the Environment*, Vol. 84, 2005). These papers are accessible through the website www.witpress.com.

prospects of a region. Therefore the present comparison is a first and perhaps crude approximation which will require further refinement.

In constructing the table that follows (Table 7) we decided to group the elements of vulnerability and territorial capital in 5 categories: Economic, social, natural, manmade - physical and institutional. We have included all elements found in Camagni's matrix of territorial capital and in the diagrams of vulnerability progression by Wisner *et al*., without exception. We did however change the terminology in some cases.

Table 11. Correlations between elements of vulnerability and elements of territorial capital.

Categories	Territorial capital (after Camagni)	Vulnerability (after Wisner *et al*.)
Economic	Fixed capital Economic externalities Limited access goods Networking and linkages of firms Inputs of R&D and technology	Economic system Local investments Local markets Debt and repayment schedules Non-development expenditures Low incomes Livelihoods at risk
Social	Social capital Entrepreneurship Creativity Know-how Proprietary networks Cooperation capability Collective action Behavioural models and values Trust relationships Associative habits	Power structures Social resources Education Appropriate skills Population change Urbanization Social groups at risk Endemic diseases
Natural	Landscape Natural resources	Deforestation Soil productivity Dangerous locations
Manmade / physical	Cultural heritage Manmade heritage Social overhead capital Infrastructures Urbanization / agglomeration	Unprotected building and infrastructures
Institutional	University research Partnerships with private and social entities Land governance and planning Collective competencies Dissemination of R&D Encouragement of receptivity	Political system Local institutions (or lack of) Press freedom Lack of disaster preparedness Ethical standards in public life

This first approach can be enriched and further developed with additional material. E.g. we have already mentioned, following Wisner *et al*., the five forms of capital, which they use in one of their models (human, social, physical, financial and natural). The elements which make up these "capitals" (skills, knowledge, health, human energy, networks, groups, institutions, infrastructure, technology, equipment, savings, credit, natural resources, land, water, fauna and flora) are all typical features of territorial capital. But even as it stands, the above table already shows interesting conceptual bridges, which promise that the analysis of territorial capital can become a useful tool for territorial vulnerability assessment.

References

Adger, W.N. and Kelly, M. (1999), *Social vulnerabililty to climate change and the architecture of entitlements*, Mitig. Adapt. Strat. Global Change, 4: 253–266.

Andrés, P. and Rodríguez, R. (eds) (2008), *Evaluacion y Prevencion de Riesgos Ambientales en Centroamérica*, Documenta Universitaria, Girona.

Assembly of European Regions (2008a), *Territorial cohesion – AER definition*, Adopted on 11 June 2008, AER Bureau Meeting, Wroclaw, www.aer.eu.

Assembly of European Regions (2008b), *Green Paper on Territorial Cohesion – Towards a harmonious and balanced development of the EU territory: Turning diversity into strength*, Document for information, Plenary meeting of AER Committee 2, Valencia, 19 September 2008, www.aer.eu.

Bagnasco, A. and Le Galès, P. (2000), *Introduction – European cities: Local societies and collective actors?*, In: Bagnasco, A. and Le Galès, P. (Eds.), "Cities in Contemporary Europe", Cambridge UK, Cambridge University Press.

Banerjee, T. (1982), *Earthquakes, urban scale vulnerability and city design: some observation*, Proceedings of the U.S.-Italy Colloqium on Urban Design and Earthquake Hazard Mitigation "Urban Scale Vulnerability", Rome, Italia, October 1981.

Bankoff, G., Frerks, G. and Hilhorst, D. (2004), *Mapping Vulnerability: Disasters, Development and People*, Earthscan.

Barry, J.M. (1997), *Rising Tide: The Great Mississippi Flood of 1927 and How It Changed America*, Touchstone Press, New York.

Bennett, G. (1970), *Bristol floods 1968: controlled survey of effects of health of local community disaster*, British Medical Journal, 21: 454-458.

Birch, E.L. and Wachter, S.M. (Eds.) (2006), *Rebuilding Urban Places After Disasters: Lesson from Hurricane Katrina*, University of Pennsylvania Press, Pennsylvania.

Birkmann, J. (2006), *Measuring vulnerability to natural hazards. Towards disaster resilient societies*, United Nations University Press.

Blaikie, P., Cannon, T., Davis, I., and Wisner, B. (1994), *At Risk: Natural Hazards, People's Vulnerability and Disasters*, Routledge, London.

Bolin, R. and Stanford, L. (1998), *The Northridge Earthquake: Vulnerability and Distaster*, Routledge, London.

Brammer, H. (1992), *Floods in Bangladesh : Vulnerability and mitigation related to human settlement*, In: Y. Aysan and I. Davis (Eds.), "Disasters and the Small Dwelling: Perspectives for the UN IDNDR", James and James, London.

Brammer, H. (2000), *Flood Hazard Vulnerability and Flood Disasters in Bangladesh*, In: Parker, D.J. (Ed.) Floods, Vol. 1, Chapter 6, Routledge, London, pp.100-115.

Brenner, N. (2004), *New State Spaces*, Oxford University Press, Oxford.

Briguglio, L. (1997), *Alternative Economic Vulnerability Indices for Developing Countries,* Report prepared for the Expert Group on Vulnerability Index, UN (DESA).

Briguglio, L., Butler, R., Harrison, D. and Filho, W.L. (1996), *Sustainable Tourism in Islands and Small States: Case Studies,* Pinter, London.

Briguglio, L. (1992), *Preliminary Study on the Construction of an Index for Ranking Countries According to their Economic Vulnerability*, UNCTAD/LDC/Misc. 4,

Burby, R. (1998), *Natural Hazards and Land Use: An Introduction*, In: R. Burby (ed.), "Cooperating with nature: Confronting natural hazards with land-use planning for sustainable communities", Joseph Henry Press, Washington, D.C. pp. 1–28.

Burby, R.J., Nelson, A.C., Parker, D.J. and Handmer, J.W. (2001), *Urban Containment Policy and Exposure to Natural Hazards : Is There a Connection?*, Journal of Environmental Planning and Management, 44(4): 475-490.

Bye, P. and Horner, M. (1998), *Easter 1998 Floods: Final Assessment of the Independent Review Team*, Environment Agency, Bristol.

Camagni, R. (2005), *The rationale for territorial cohesion and the place of Territorial Development Policies in the European Model of Society*, Power Point presentation, International seminar on "Territorial Cohesion and the European Model of Society", Lincoln Institute of Land Policy, Vienna, 11-13 July 2005, www.intelligentcoast.es/downloads/89_archiv6289_25834.

Camagni, R. (2007), *Towards a concept of territorial capital*, Paper presented at a Joint Congress of the European Regional Science Association (47th Congress) and ASRDLF (Association de Science Régionale de Langue Française (44th Congress), 29th August – 2nd Sptember 2007, Paris, http://sadapt.inapg.inra.fr/ersa2007/papers_number.php?paper=987.

Carpenter, S.R., Walker, B., Anderies, J.M. and Abel, N. (2001) *From metaphor to measurement: Resilience of what to what?,* Ecosystems 4(8): 765-781.

CEC (Commission of the European Communities) (2004), *Third Report on Economic and Social Cohesion*, Commission of the European Communities, COM(2004) 107 final, 18.2.2004, Brussels.

Ceudech, A. (2004) *La vulnerabilità dei sistemi urbani al rischio sismico*, In: A. Galderisi (Ed.), "Città e Terremoti", Gangemi Editore, Roma.

Ceudech, A. (2007) *Systemic vulnerability and seismic risk in the historical town of Naples*, Urbanistica, 134, Inu Edizioni, Roma.

Chan, N.W. (1995), *A Contextual Analysis of Flood Hazard Management in Peninsular Malaysia*, Unpublished PhD thesis, Middlesex University, London.

Changnon, S.A. (ed.) (1996), *The Great Flood of 1993: Causes, Impacts and Responses*, Westview Press, Boulder, Colorado.

Cherveriat, C. (2000), *Natural disasters in Latin America and the Caribbean: An overview of risk*, Working Paper No 434, Inter-American Development Bank, Research Department.

Cutter, S.L. (1996), *Vulnerability to environmental hazards*, Progress in Human Geography, 20(4): 529-539.

Cutter, S.L. (2003), *The vulnerability of science and the science of vulnerability*, Annals of the Association of American Geographers, 93(1): 1-12.

Cutter, S.L., Boruff, B.J. and Shirley, W.L. (2003), *Social vulnerability to environmental hazards*, Social Science Quarterly, 84(2), pp. 242-261.

Dandoulaki, M. and Delladetsima, P. (2004), *Seismic protection in an island setting*, Proceedings of the international workshop on "Restoration of historical buildings in seismic areas: The case of settlements in the Aegean", 24–26 May, Mytilini (Lesvos), Greece, 66–72.

Dandoulaki, M. and Parcharidis, I. (2001,) *Guidelines for upgrading earthquake emergency planning in the city of Patras: Organisational and urban planning aspects*, Geographies, 1: 103–108 (in Greek).

Davoudi, S. (2005), *Understanding territorial cohesion*, Planning Practice and Research, 20(4): 433-441.

Davoudi, S., Evans, N., Governa, F. and Santangelo, M. (2008), *Territorial governance in the making: Approaches, methodologies, practices*, Boletin de la A.G.E., 46: 33-52.

DCLG (Department for Communities and Local Government) (2006), *Planning Policy Statement 25: Development and Flood Risk*, DCLG, London.

De Marchi, B., Scolobig A., Delli Zotti G. and Del Zotto, M. (2007), *Risk construction and social vulnerability in an Italian Alpine Region,* FLOODsite Report No. T11-2006-08, ISIG, Gorizia.

DEFRA (Department for Environment, Food and Rural Affairs) (2004), *Catchment Flood Management Plans, Vol. 1: Policy Guidance*, DEFRA, Welsh Assembly Government, Environment Agency, London, Cardiff and Bristol.

DEFRA (Department for Environment, Food and Rural Affairs) (2006), *Shoreline management plan guidance, Volume 2: Procedures*, DEFRA, London.

Delladetsima, P. M., Dandoulaki, M. and Soullakelis, N. (2006), *An Aegean island earthquake protection strategy: an integrated analysis and policy methodology*, Disasters, 30(4): 469−502.

Di Sopra, L. (1981), *Gli aspetti spazio-temporali dei disastri: approccio urbanistico*, In: Cattarinussi, B. and Pelanda, C. (Eds.), "Disastro e Azione Umana", Franco Angeli, Milano.

Di Sopra, L., Pelanda, C. and Strassoldo, M. (1981), *Vulnerabilità, stabilità e degenerazione dei sistema: Nota generale di sintesi*, In: Cattarinussi, B. and Pelanda, C. (Eds.), "Disastro e Azione Umana", Franco Angeli, Milano.

Dilley, M. and Boudreau, T.E. (2001), *Coming to terms with vulnerability: A critique of the food security definition*, Food Policy, 26: 229–247.

Dow, K. (1992), *Exploring differences in our common future(s): The meaning of vulnerability to global environmental change*, Geoforum, 23: 417–436.

Downing, T.E. and Patwardhan, A. (2003), *Vulnerability Assessment for Climate Adaptation*, APF Technical Paper 3, United Nations Development Programme, New York City, NY, final draft.

Drabek, T.E. (1996) *Disaster Evacuation Behaviour of Tourists*, Publication MG 58. NHRAC, University of Colorado, Boulder, CO.

Drobot, S., Benight C. and Gruntfest E. (2007), *Risk factors for driving into flooded roads*, Environmental Hazards, 7: 227-234.

Environment Agency (2007), *Thames Estuary Flood Vulnerability Baseline Assessment, Phase 3 Studies – Work Element 6.1*., Environment Agency, London.

Environment Agency (2008), *Thames Estuary 2100, Phase 3 (i) Interim Flood Risk Management Plan, Sub-Product 4 – Implementation*, Draft 21.02.08, Environment Agency, London.

EPPO (Earthquake Planning and Protection Organisation) (1998), *Guidelines for upgrading emergency planning in Patras city (Greece): Organisational and urban planning aspects*, A multidisciplinary project for urban and emergency planning in seismic regions (unpublished report in Greek).

ESPON Hazards project (2005), *The Spatial Effects and Management of Natural and Technological Hazards in general and in relation to Climate Change*, Final Report, European Commission.

ESPON project 2.3.2 (2006), *Governance of Territorial and Urban Policies From EU to Local Level*, Final Report, European Commission.

ESPON project 3.1 (2004), *Integrated Tools for European Spatial Development – Towards an ESPON Glossary*, Final Report Part C – Annex, European Commission.

EU Editorial Group (2006), *The Territorial State and Perspectives of the European Union Document: Towards a Stronger European Territorial Cohesion in the Light of the Lisbon and Gothenburg Ambitions*, First Draft, Elaborated by the Editorial Group as of 26 June 2006, Presented to all 25 Member States on 26 June 2006, www.gec-eran.org/documents/errn/EU_Territorial_Agenda.

EU Informal Ministerial Meeting (2005), *Scoping document and summary of political messages for an assessment of the Territorial State and Perspectives of the European Union*, Endorsed for further development by the Ministers for Spatial Development and the European Commission at the Informal Ministerial Meeting on

Regional Policy and Territorial Cohesion, 20-21 May 2005 in Luxembourg, www.sharedspaces.nl/docs/internationaal/Scoping.

EU Informal Ministerial Meeting (2007), *Territorial Agenda of the European Union: Towards a More Competitive and Sustainable Europe of Diverse Regions*, Agreed on the occasion of the Informal Ministerial Meeting on Urban Development and Territorial Cohesion in Leipzig on 24-25 May 2007.

EU STREP VI Framework Program (2007), *Applied Multi Risk Mapping of Natural Hazards for Impact Assessment (ARMONIA),* Research Project, 2004-2007.

European Commission (2007a) *Applied Multirisk Mapping of Natural Hazards for Impact Assessment – 2004-2007*, the Armonia Project, Deliverable 5.1, EU STREP VI.

European Commission (2007b) *Systems Integrated for Security Management Activities – 2004-2007*, Interreg IIIB SISMA Project.

Fera, G. (1991) *La città antisismica*, Gangemi Editore.

Folke, C., Carpenter, S. et al. (2002), "Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformation", *Scientific Background Paper on Resilience for the process, World Summit on Sustainable Development* on behalf of the Environmental Advisory Council to the Swedish Government, http://www.sou.gov.se/mvb/pdf/resiliens.pdf.

Fortune J. and Peters, G. (1995), *Learning from failure*, John Wiley & Sons, Great Britain.

Funtowicz, S. and Ravetz, J. (1990), *Uncertainty and quality in Science for policy,* Kluwer Academic Publishers, The Netherlands.

Fussel, H.M. and Klein, R.J.T. (2006), *Climate Change Vulnerability Assessment: An Evolution of Conceptual Thinking*, Climate Change*,* Vol. 75(3), pp. 301-329.

Galderisi A., Ceudech, A. and Pistucci, M. (2008), *A method for na-tech risk assessment as supporting tool for land use planning mitigation strategies*, Natural Hazards*,* 46(2): 221-241.

Galderisi, A. (2004), *Esposizione, Vulnerabilità e gestione dell'emergenza nei grandi sistemi urbani*, In: Galderisi A., "Città e Terremoti", Gangemi Editore, Roma.

Galderisi, A. (2006), *I presupposti teorici: vulnerabilità e resilienza dei sistemi urbani*, In: Menoni, S. (ed.) "La salvaguardia dei valori storici, culturali e paesistici nelle zone sismiche italiane", Gangemi Editore, Roma.

Galderisi, A. and Ceudech, A. (2008), *Dalle tecniche per la conoscenza agli strumenti urbanistici per la mitigazione del rischio idrogeologico in ambito urbano*, Proceedings of the *XXIX National Conference of Regional Sciences,* Bari.

Galderisi, A. and Menoni, S. (2007), *Towards a risk informed planning process: the main outcomes of the Armonia Project,* Proceedings of the XXI AESOP Congress

"Planning for the risk society. Dealing with uncertainty, challenging the future", 11-14 July 2007, Naples, Italy.

German Presidency (2007), *The Territorial State and Perspectives of the European Union: Towards a Stronger European Territorial Cohesion in the Light of the Lisbon and Gothenburg Ambitions*, A Background Document for the Territorial Agenda of the European Union, Based on the Scoping Document discussed by Ministers at their Informal Ministerial Meeting in Luxembourg in May 2005, www.bmvbs.de/Anlage/original_1005296/The-Territorial-State-and-Perspectives-of-the-European-Union.

Governa, F. and Santangelo, M. (2006), *Territorial governance and territorial cohesion in the European scenario*, paper presented at an international conference on "Shaping EU Regional Policy: Economic, Social and Political Pressures", 8th-9th June 2006, University of Leuven.

Granger, K., Jones, T., Leiba, M. and Scott, G. (1999), *Community risk in Cairns. A multihazard risk assessment*, AGSO, Australia.

Green, C.H., Emery P.J., Penning-Rowsell E.C., Parker D.J. (1984), *The health effects of flooding, a survey at Uphill, Avon*, Flood Hazard Research Centre, Middlesex University, Enfield.

Gunderson, L.H. and Holling, C.S. (Eds.) (2002) *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press, Washington, DC.

Handmer, J.W. and Smith D.I. (1983), *Health hazards of floods : Hospital admissions for Lismore*, Australian Geographical Studies, 21: 221-230.

Hewitt, K. (1997), *Regions of Risk: A Geographical Introduction to Disasters*, Longman, London.

Hilhorst, D. (2004), *Complexity and Diversity: Unlocking Social Domains of Disaster Response*, In: G. Bankoff, G. Frerks and D. Hilhorst (Eds.) *Mapping Vulnerability – Disasters, Development and People*, Earthscan, London.

Holling, C.S. (1973) *Resilience and stability of ecological systems*, Ann. Rev. of Ecol. and Syst., 4: 1-23.

HUA (Harokopion University of Athens) (2003), *Social and Economic Impacts of the Seismic Event of 7/9/1999 on Manufacturing / Trade Firms and Employment in Western Athens: Analysis of Trends and Proposals for Policy Measures*, Research Project assigned by the "Earthquake Planning and Protection Organization", Athens (in Greek).

Islam, K.M.N. (2005), *Flood Loss Potentials in Non-agricultural Sectors: Assessment Methods and Standard Loss Database for Bangladesh*, Palok Publishers, Dhaka.

Islam, K.M.N. (2006), *Impacts of Flood in Bangladesh: Micro and Macro Level Analysis,* AH Development Publishing House & Community Development Library, Dhaka.

Johnson, C.L, Penning-Rowsell, E.C. and Parker, D.J. (2007), *Natural and imposed injustices: The challenges in implementing 'fair' flood risk management policy in England*, Geographical Journal, 173(4): 374-390.

Kasperson, J.X., Kasperson, R.E. and Turner, B.L. (1996) *Regions at Risk: Comparisons of Threatened Environments*, Washington DC: United Nations University Press.

Konvitz, J.W. (2000), *Changing economies: The territorial dimension*, Informationen zur Raumentwicklung, Heft 11/12.2000: 657-663.

Kumpulainen, S. (2006), *Vulnerability Concepts in Hazard and Risk Assessment*, Geological Survey of Finland, Special Paper 42: 65-74.

Kwi-Gon, K. (1999), *Flood hazard in Seoul : A preliminary assessment*, In: J.K. Mitchell (Ed.) "Crucibles of Hazard : Mega-Cities and Disasters in Transition", United Nations University Press, Tokyo, pp. 92-118.

Ledoux, B. (1999), *Guide pour la conduite des diagnostiques de vulnérabilité aux inondations pour les entreprises industrielles*, Ministère de l'Aménagment du Territoire et de l'Environment.

Lekkas, E. (2000), *A multidisciplinary project for urban and emergency planning in seismic regions: the case of Pyrgos city (W. Peloponnese Greece)*, 6th International Conference on Seismic Zonation, Earthquake Engineering Research Institute (EERI), Vol. II, 1017-1022, California http://www.elekkas.gr/view_paper.php?pid=127.

Lewis, J. (1990) *The vulnerability of small island states: The need for holistic strategies*, Disasters, 14(3): 241–249.

Lewis, J. (1999), *Development in Disaster-prone Places: Studies of Vulnerability*, Intermediate Technology Publications, London.

Liverman, D.M. (1990), *Vulnerability to global environmental change*, In: R.E. Kasperson, K. Dow, D. Golding and J.X. Kasperson (Eds.), "Understanding Global Environmental Change: The Contributions of Risk Analysis and Management", Clark University, Worcester, MA, pp. 27–44.

Long, N. (2001), *Development Sociology: Actor Perspectives,* Routledge, London.

Mahmud, N. (2000), *Flood Disasters and Population Displacement : The case of Ormoc City, the Philippines*, In: D.J. Parker (Ed.) *Floods*, Vol. 1, Routlege, London, pp. 401-411.

Mani, D. (2001), *Vulnerability, Vulnerability Analysis and Asset Management*, Second Thematic Training Course of the United Nations Centre for Regional Development (UNCRD), 1-30 Nov. 2001, Nagoya, Japan.

Menoni, S. (Ed.) (2004), *La salvaguardia dei valori storici, culturali e paesistici nelle zone sismiche italiane: Proposte per un manuale*, Gangemi Editore, Roma.

Menoni, S., Pergalani, F., Boni, M.P. and Petrini, V. (2007), *Lifelines earthquake vulnerability assessment: a systemic approach*, In: I. Linkov (cur.), "Risk

Management Tools for Port Security, Critical Infrastructure, and Sustainability", Springer and Verlag, pp. 111-132.

Mitchell, J.K. (Ed.) (1999), *Crucibles of Hazard: Mega-Cities and Disasters in Transition*, United Nations Press, New York.

Mitchell, J.K., Devine, N. and Jagger, K. (1989) *A Contextual Model of Natural Hazard*, The Geographical Review,79: 391–409.

Morrow, B. H. (1999), *Identifying and Mapping Community Vulnerability*, Disasters, 23(1): 1-18.

Munich Re Group (2003), *Topics - Annual review: Natural Catastrophes 2002,* http://www.munichre.com/publications/302-03631_en.pdf.

Musser, L. (2002), *Vulnerability Bibliography,* Center for Science and Technology Policy Research, University of Colorado-Boulder.

NKUA (National and Kapodistrian University of Athens) (1996), *A multidisciplinary project for urban and emergency planning in seismic regions: the case of Pyrgos city (W. Peloponnese Greece)*, Research project (Unpublished final report in Greek).

NKUA, UA and MA (National Kapodistrian University of Athens, University of the Aegean and Ministry of the Aegean) (1998), *Seismic Protection Policy for Islands*, Research report, Volumes I–II, NKUA, Athens (in Greek).

NOAA (National Oceanic and Atmospheric Administration) - Coastal Services Center (no date) *Vulnerability Assessment Techniques and Applications (VATA)*, http://www.csc.noaa.gov/vata/intro2.html.

NTUA (National Technical University of Athens) (1996), *Detection of areas with the same kinematic behaviour by geodetic methods in the area of the Agia Triada fault in the city of Patras,* unpublished final report of a Research project (in Greek).

OECD (Organization for Economic Co-operation and Development) (2001), *Territorial Outlook*, OECD, Paris.

OECD (Organization for Economic Co-operation and Development, Assistance Committee) (1994), *Guidelines for Aid Agencies on Disaster Mitigation*, OECD, Paris.

Parker, D.J. (1999a) *Disaster response in London: A case of learning constrained by history and experience*, In: J.K. Mitchell (Ed.) "Crucibles of Hazard : Mega-Cities and Disasters in Transition", United Nations University Press, Tokyo, pp.186-247.

Parker, D.J. (1999b), *Criteria for Evaluating the Condition of a Tropical Cyclone Warning System*, Disasters, Vol. 23(3): 193-216.

Parker, D.J. (2003), *Managing Collision: Urban Development and Water Crises in Europe*, Keynote paper presented at conference on "Managing European Water Crises: From Lessons Learned to Future Resilience", Dorint Sofitel, Amsterdam, 6-7 November 2003.

Parker, D.J. and Penning-Rowsell, E.C. (2005), *Dealing with disasters*, In: J. Hunt (Ed.) "London's Environment: Prospects for a Sustainable World City", Imperial College Press, London, pp.175-202.

Parker, D.J. and Tapsell, S.M. (1997), *Hazard and Disaster Management Learning and Failure in the London Megacity*, Geography and Environmental Management Paper No. 29, Middlesex University, Enfield.

Parker, D.J., Priest S. and Tapsell S.M. (2008), *Modelling the damage reducing effects of flood warnings, FLOODsite Final Report,* Report No. T10-07-02, Flood Hazard Research Centre, Middlesex University, London.

Pelling, M. (2003), *The Vulnerability of Cities – Natural Disasters and Social Resilience,* Earthscan Publications, London.

Pelling, M. and Uitto, J.I. (2001), *Small Island Developing States: Natural Disaster Vulnerability and Global Change*, Environmental Hazards, 3(2): 49–62.

Pitt, M. (2008), *Learning lessons from the 2007 floods*, The Pitt Review, Cabinet Office, London.

Ruin, I., Gaillard, J-C. and Lutoff, C. (2007), *How to get there ? Assessing morotrists's flash flood risk perception of daily intineraries*, Environmental Hazards, 7(3): 227-234.

Sapountzaki, K. (2005), *Coping with seismic vulnerability: Small manufacturing firms in western Athens*, Disasters, 29(2): 95-212.

Sarewitz, D. and Pielke Jr., R.A. (Eds.) (2000), *Extreme Events: Developing a Research Agenda for the 21st Century*, Environmental and Societal Impacts Group, National Center for Atmospheric Research, Boulder, Co.

Schön, P. (2005), *Territorial Cohesion in Europe?*, Planning Theory and Practice, 6(3): 389-400.

Skjerpen, A. (2008), *Green Paper Territorial Cohesion*, Power Point presentation, 3 April 2008, www.northsea.org/nsc/executive_committee/0804_gtb/Green_paper_Territorial_Cohesion_arve_ppt.

Steinfuhrer, A. and Kuhlicke, C. (2007), *Social vulnerability and the 2002 flood, Country Report Germany (Mulde River*), *FLOODsite*, Report No. T11-07-08, UFZ, Leipzig.

Tapsell, S.M. (2000), *Follow-up Study of the Health Effects of the 1998 Easter Flooding in Banbury and Kidlington,* Report to the Environment Agency, Thames Region, Flood Hazard Research Centre, Middlesex University, Enfield.

Tapsell, S.M., Tunstall, S.M. and Wilson, T. (2003), *Banbury and Kidlington - Four Years After the Flood: An Examination of the Long-Term Health Effects of Flooding*, Report to the Environment Agency, Thames Region, Flood Hazard Research Centre, Middlesex University, Enfield.

Tapsell, S.M., Tunstall, S.M., Penning-Rowsell, E.C. and Handmer, J.W. (1999), *The Health Effects of the 1998 Easter Flooding in Banbury and Kidlington*, Report to the

Environment Agency, Thames Region, Flood Hazard Research Centre, Middlesex University, Enfield.

Thieken, A.H., Kreibich, H., Muller, M. and Merz, B. (2005), *Flood damage and influencing factors: new insights from the August 2002 flood in Germany*, Water Resources Research, 41: 1-16.

Thieken, A.H., Kreibich, H., Muller, M. and Merz, B. (2007), *Coping with floods: preparedness, response and recovery of flood-affected residents in Germany in 2002*, Hydrological Sciences, 52(5): 1016-1037.

Thieken, A.H., Petrow, Th., Kreibich, H. and Merz, B. (2006), *Insurability and mitigation of flood losses in private households in Germany*, Risk Analysis, 26(2): 383-395.

Tierney, K. (2006), *Social Vulnerability: A New Paradigm for Disaster Research*, presentation in the IBHS Annual Conference, 16th November 2006, Orlando, FLA.

Timmermann, P. (1981), *Vulnerability, Resilience and the Collapse of Society*, No. 1 in Environmental Monograph, Institute for Environmental Studies, University of Toronto, Toronto.

Tunstall, S., Tapsell, S. and Fernandez-Bibao, A. (2007), *Vulnerability and flooding: a re-analysis of FHRC data, Country Report England and Wales*, *FLOODsite*, Report No. T11-07-11, Flood Hazard Research Centre, Middlesex University, London.

Tunstall, S.M., Parker, D.J., Twomey, G., Doizy, A. and Sangster, E. (1991), *The Severn Floods of January and February 1990*, Report to the National Rivers Authority, Flood Hazard Research Centre, Middlesex University, London.

UN/ISDR (2004), *Terminology: Basic terms of disaster risk reduction,* http://www.unisdr.org/eng/library/.

UNDHA (1993), *Internationally Agreed Glossary of Basic Terms Related to Disaster Management,* DNA/93/36, United Nations Department of Humanitarian Affairs, Geneva, Switzerland.

UNDP (Bureau for Crisis Prevention and Recovery) (2004), *Reducing Disaster Risk – A Challenge for Development,* www.undp.org/bcpr.

UNINA / Di.Pi.S.T. (2003), *The seismic risk protection: vulnerability, analysis and requalification of the physical and built environment with innovative techniques*, CIPE-MURST Research Project, Napoli.

UNINA / Di.Pi.S.T. (2004), *The Safeguard of the Historical, Landscape and Cultural Heritage of the Italian Seismic Risk Areas,* Italian Research Project, Napoli 2002-2004.

UNINA / Di.Pi.S.T. (2008), *Neighbourhood Vulnerability to Natechs*, UNINA-DIPIST Activity Programme 2005-2008.

University of Patras (1996), *Geotechnical database development and evaluation for the wider area of Patras, compilation of the relevant maps,* Research project, unpublished final report (in Greek).

University of Patras (1997), *Development of a seismotectonic database and estimation of the most probable ground motion in the Patras region*, Research project, unpublished final report (in Greek).

University of Patras (1997), *Effects of site conditions on seismic ground response in the city of Patras,* Research project, unpublished final report (in Greek).

University of Patras (1997), *Vulnerability study of the Patras city,* Research project, unpublished final report (in Greek).

Vetere, A.-L., Heikkila, A.M., Bouchon S., Nordvik, J.P., Runarson, J., Bjurman, U., Gell, T., Schieb, PA., Lahidji, R. and Stevens, B. (2004), *Systemic risks and lessons learned*, JRC-SRSA-OECD Joint Seminar in Karslkoga, Sweden, 20 September 2004, Report EUR 21404 EN.

Villagrán de León, J.C. (2006), *Vulnerability – A Conceptual and Methodological review,* United Nations University (UNU-EHS), Publication Series of UNU-EHS, No 4/2006.

Wassenhoven, L. (2008), *Territorial cohesion: New directions for spatial development and their significance for Greece*, International and European Policy, 10: 247-263 (in Greek).

Werrity, A., Houston D., Ball T., Tavendale A. and Black A. (2007), *Exploring the Social Impacts of Flood Risk and Flooding in Scotland*, Scottish Executive Social Research, Scottish: Executive, Edinburgh.

Winchester, P. (2000), *The Political Economy of Riverine and Coastal Floods in South India*, In: D.J. Parker (Ed.), "Floods", Vol. 1, Routlege , London, pp.56-68.

Wisner, B. (2000), *From "Acts of God" to "Water Wars"- The urgent analytical and policy role of political ecology in mitigating losses from flood: A view of South Africa from Central America*, In: D.J. Parker (Ed.) *Floods*, Vol.1, Routlege, London pp.89-99.

Wisner, B., Blaikie, P., Cannon, T. and Davis, I. (2004), *At Risk: Natural hazards, people's vulnerability and disasters*, 2nd edition, Routledge, London.

Zoleta-Nantes, D.B. (2000), *Flood Hazard Vulnerabilities and Coping Strategies of Residents of Urban Poor Settlements in Metro Manila, The Philippines*, In: D.J. Parker (Ed.) *Floods*, Vol. 1, Routlege, London, pp.69-88.