



The importance of vulnerability issues as a major aspect of integral risk management of natural hazards



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Is vulnerability a major issue ?

December 2003 - 3 Earthquakes 6.5(Mw)



> Taiwan :

- No Damage
- No Victim



> California :

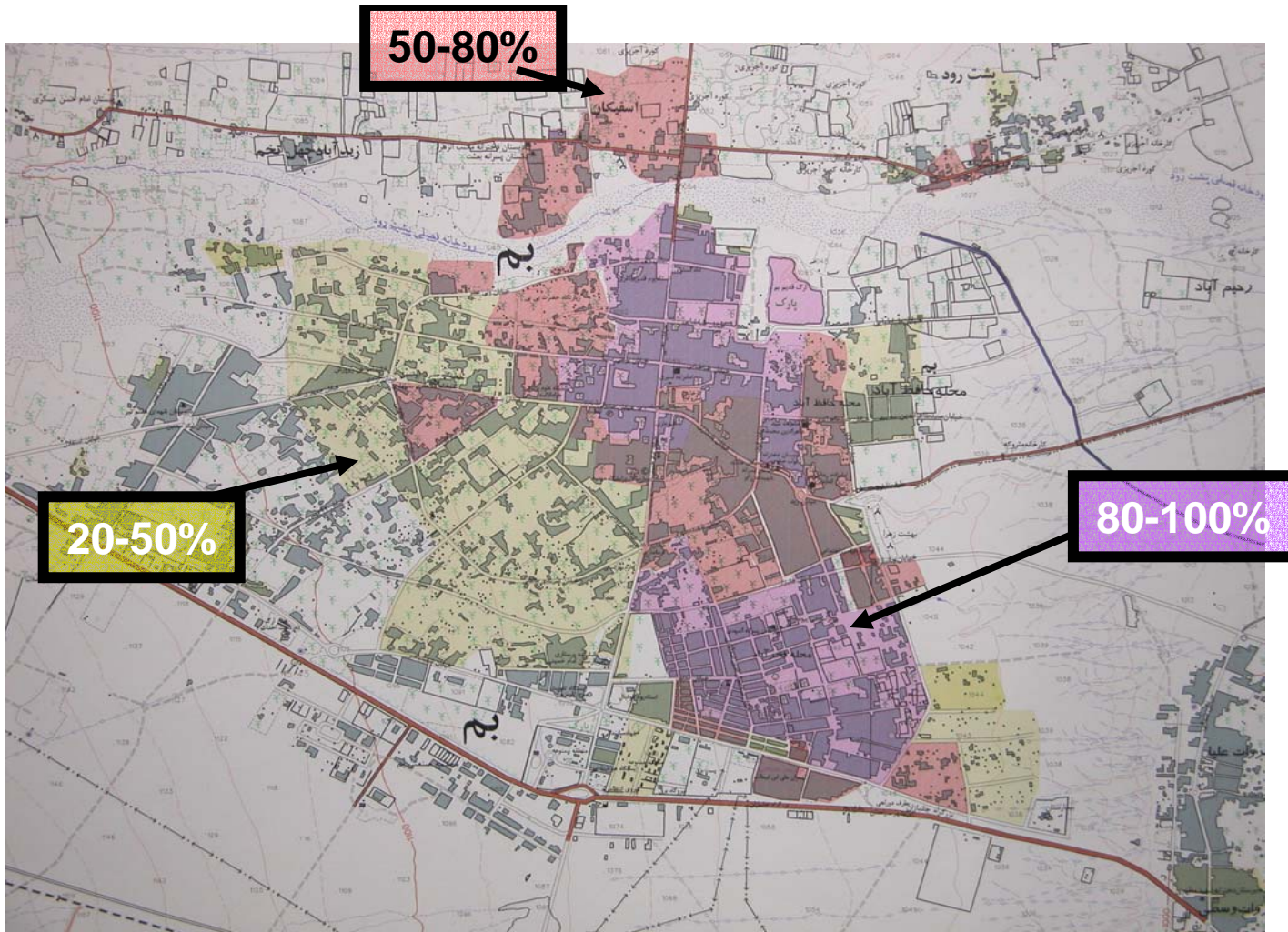
- No Damage
- No Victim



> Iran (Bam):

- 80% of the City destroyed
- 38 000 Victims

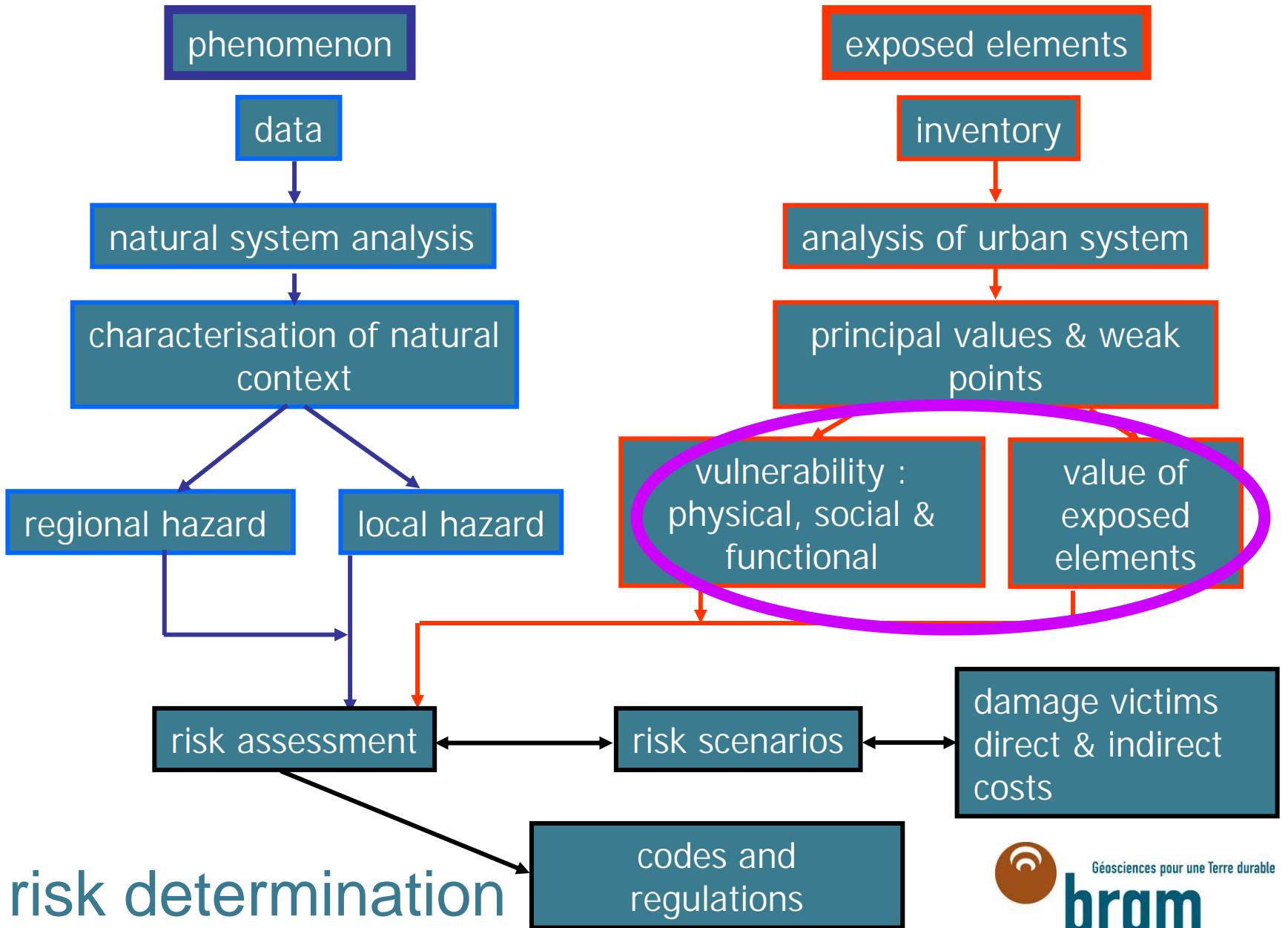
Bam (Iran), December 26, 2003



Destruction %

Bam (Iran), 26 décembre 2003





Physical and functional vulnerability

Resistance of physical elements

depends on the morphological and structural features of buildings or infrastructures which enable them to absorb the stress determined by a given hazard (earthquake, fires, etc.)



Friuli 1976
earthquake

Naples 1980
earthquake

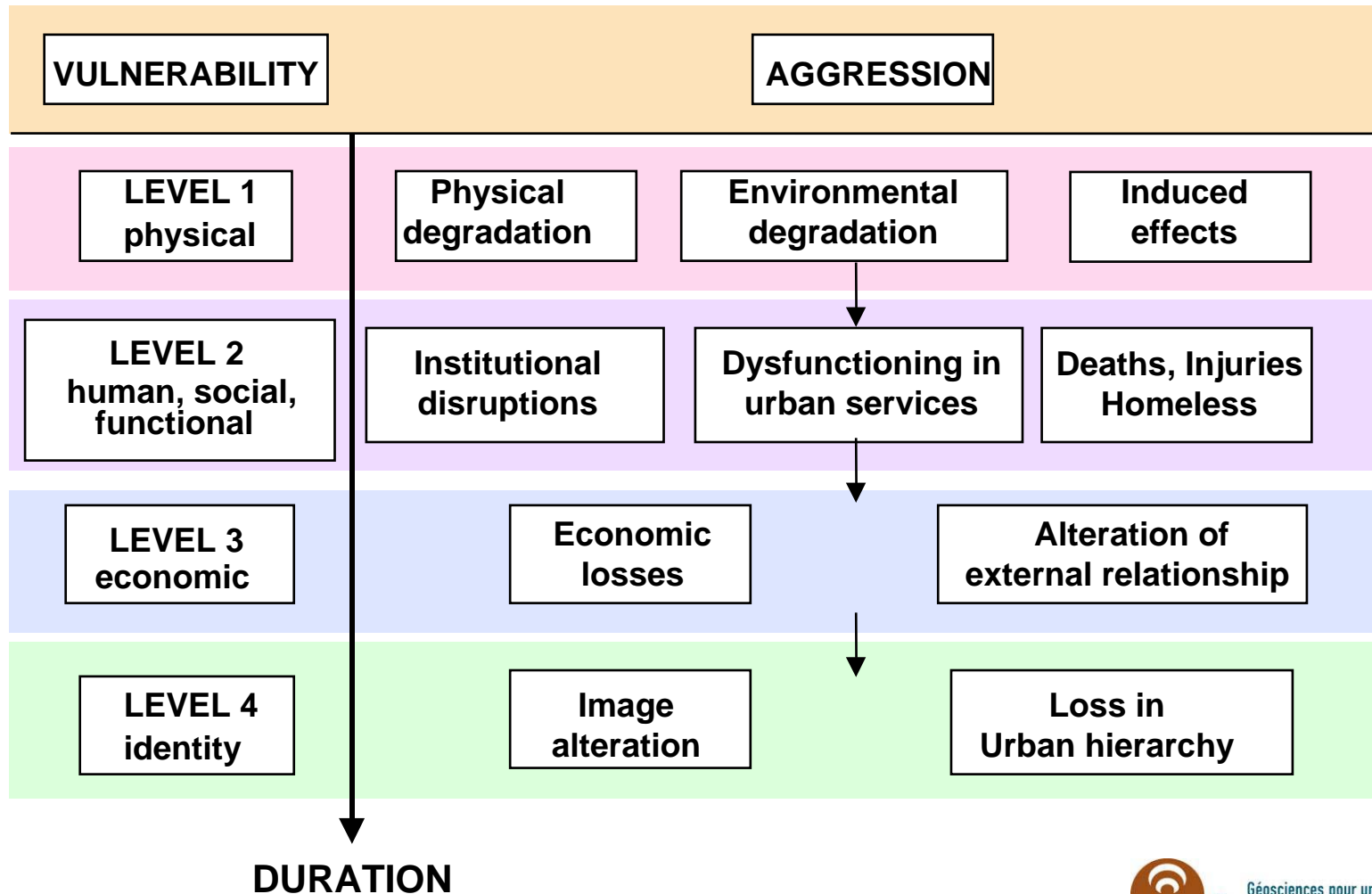


Capacity of urban or territorial system to cope with the demand in the post-event phase

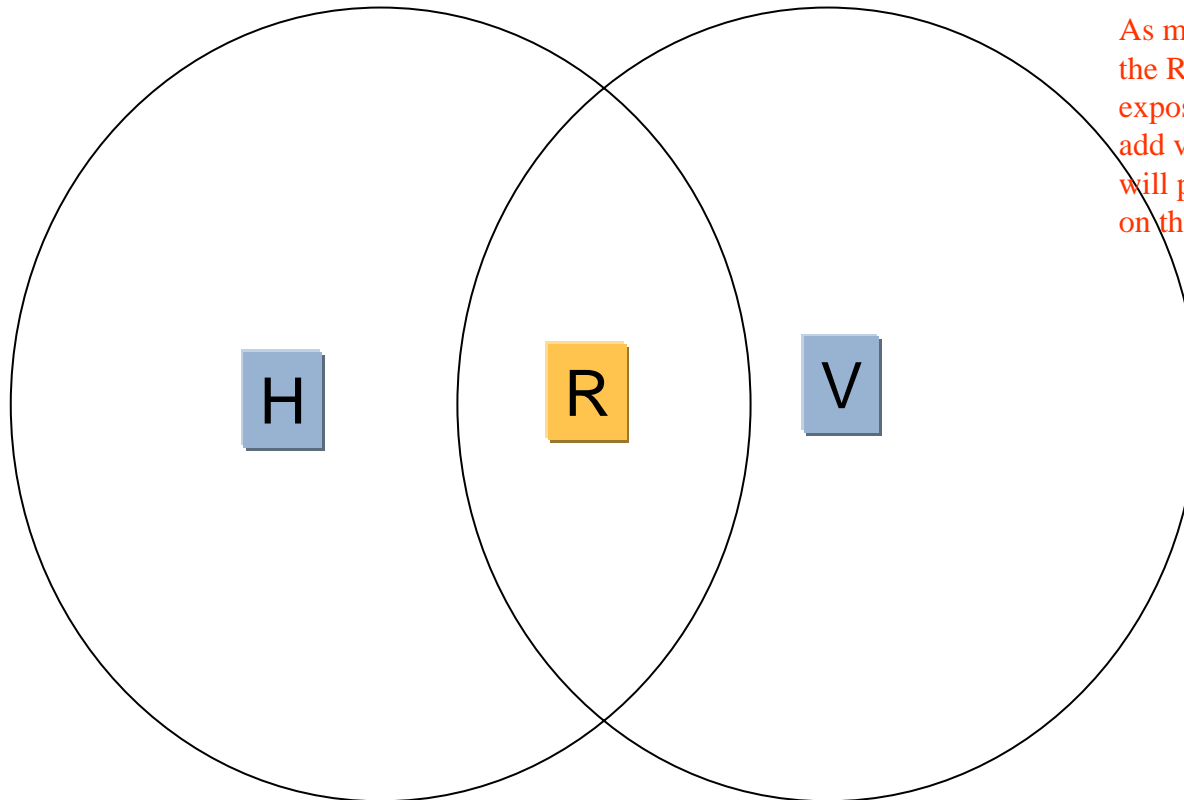
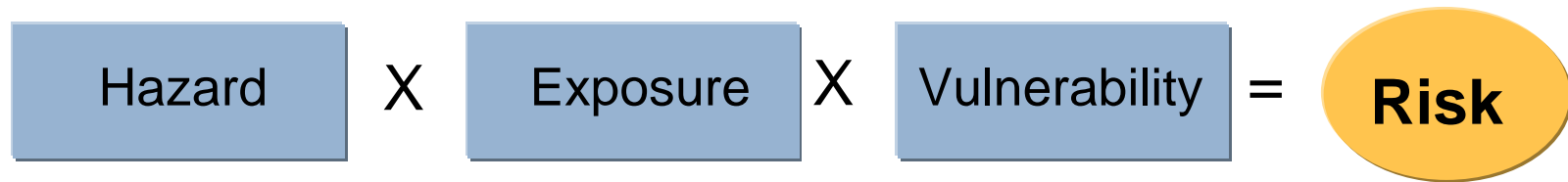
depends on spatial and functional organization of urban tissues which enable them to supply the demand for activities.



vulnerability levels

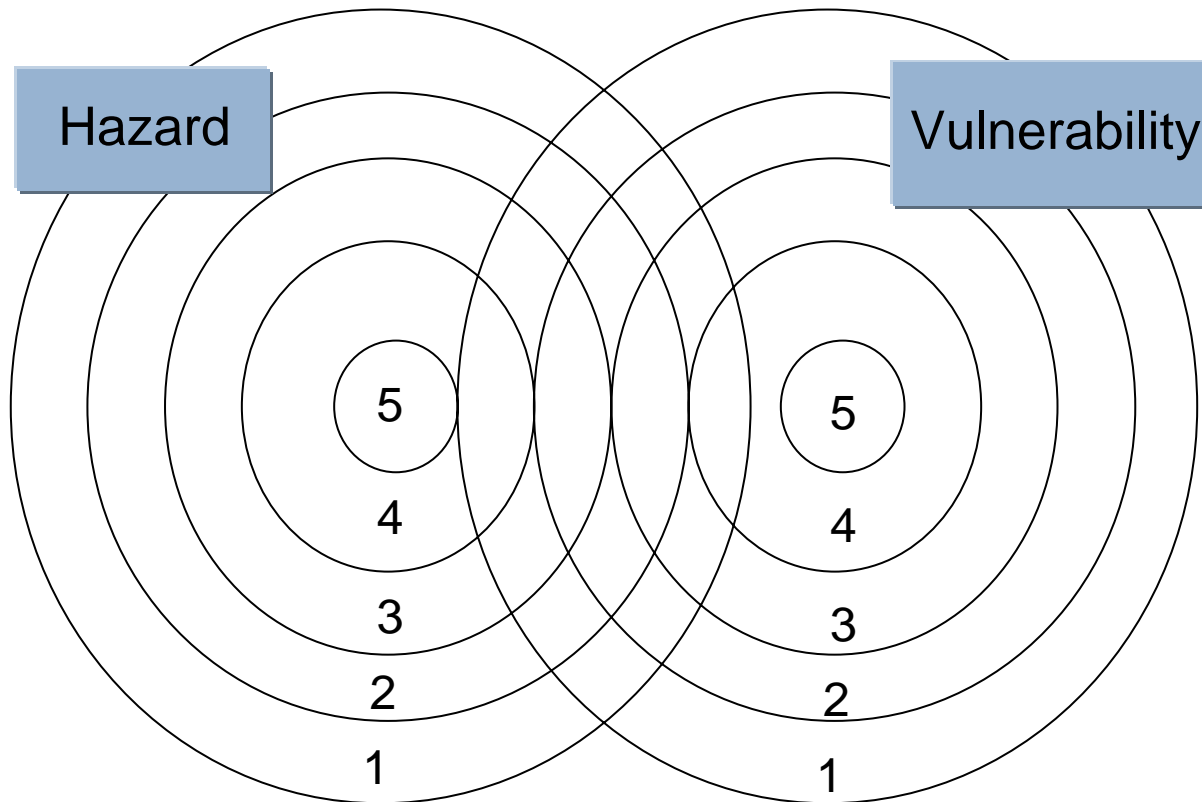
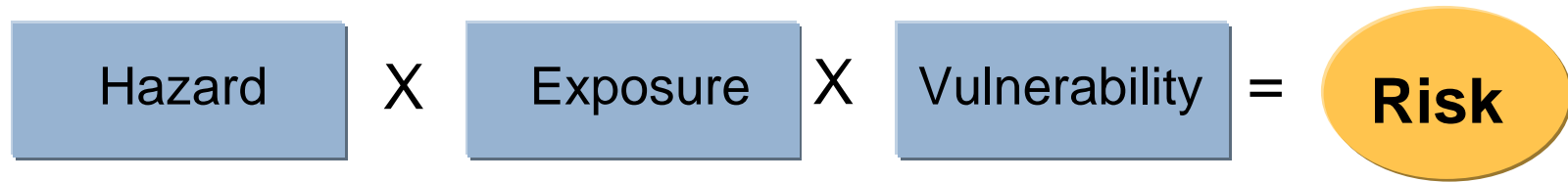


Vulnerability in risk evaluation

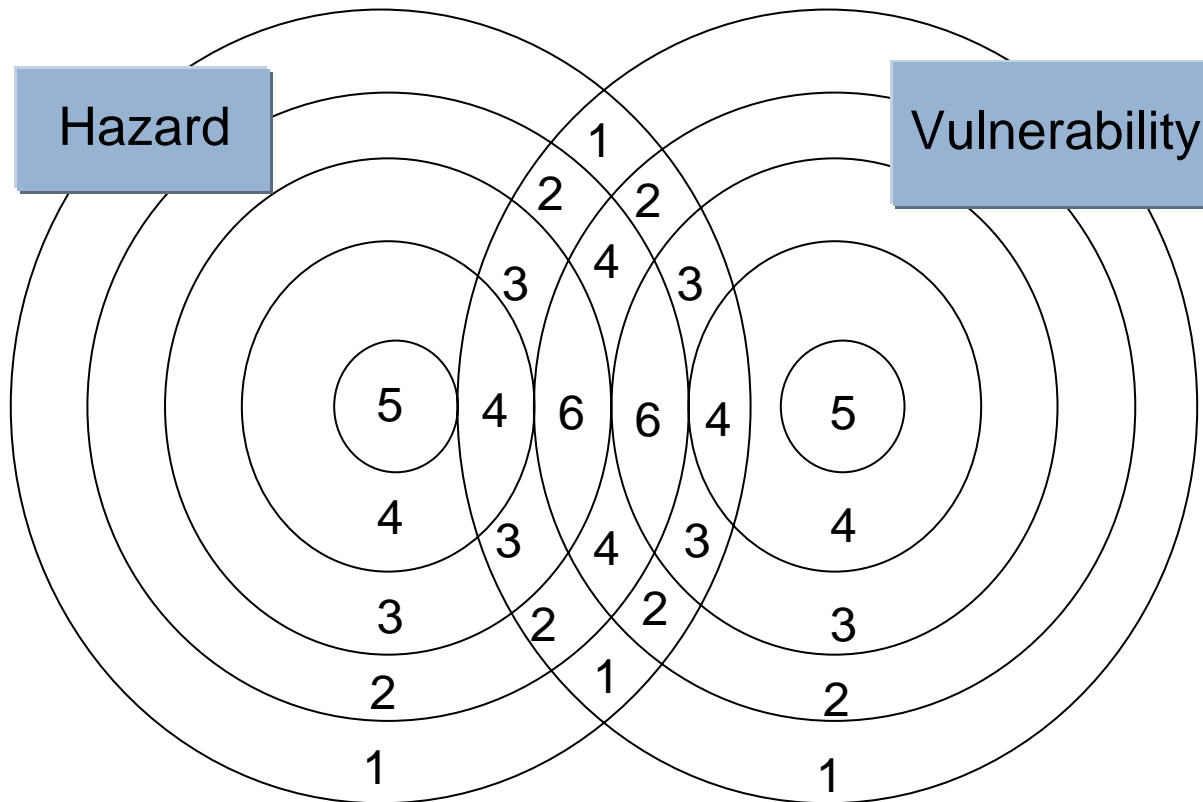
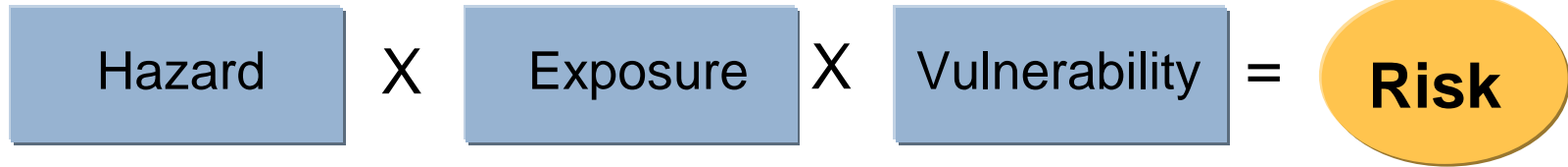


As may be seen in following slides, the R zone here is not Risk but exposure it becomes risk when you add values (as in slide 8). Hence, I will put E for exposure instead of R on the graph here.

Vulnerability in risk evaluation

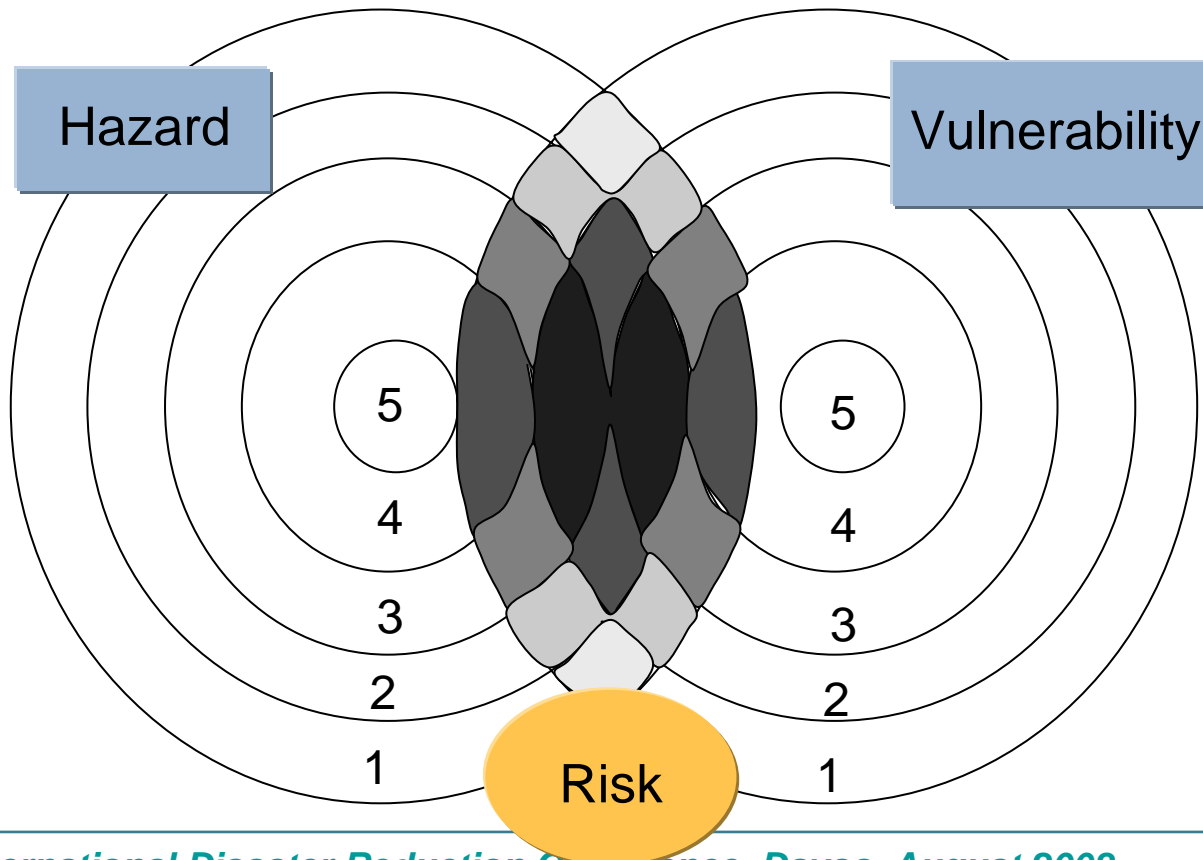


Vulnerability in risk evaluation



Vulnerability in risk evaluation

$$\text{Hazard} \times \text{Exposure} \times \text{Vulnerability} = \text{Risk}$$



Risk Reduction

reducing hazard



Identify Hazards and level of threat

reducing exposure



Land Use Planning

reducing vulnerability

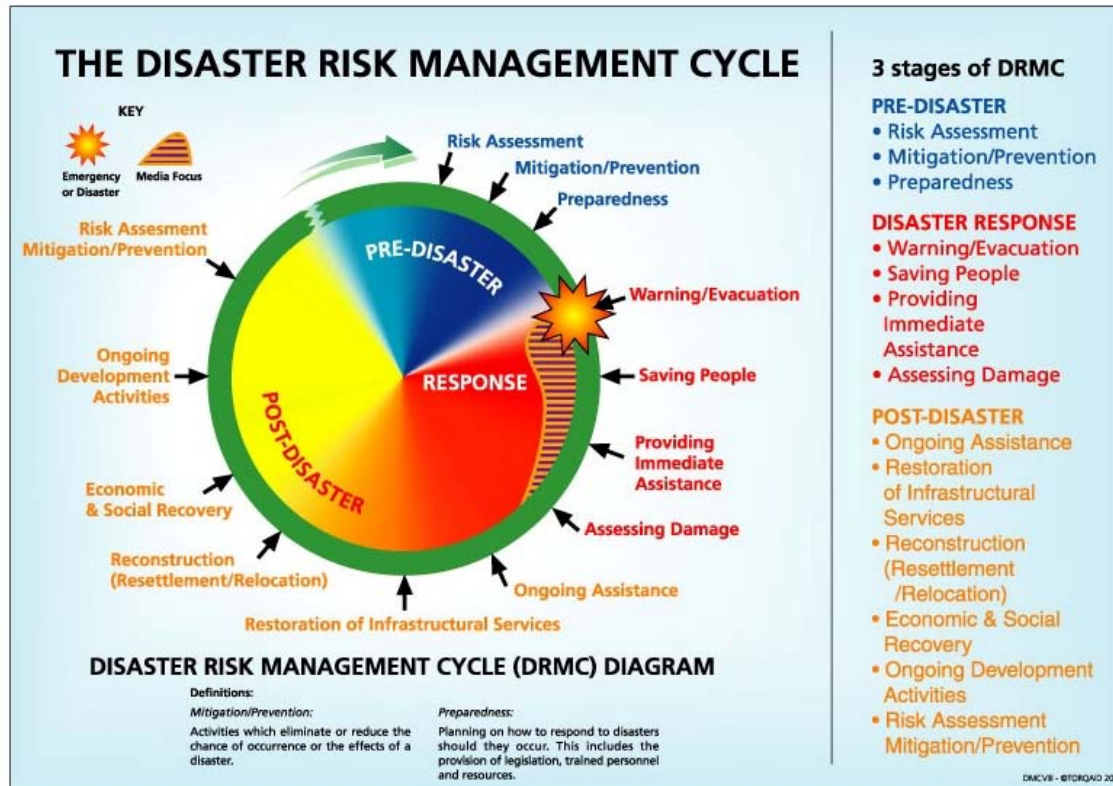


Assesment of Systemic and Physical Vulnerabilities

Need to collect all available information and data and to use it for multi-risk assessment



Focus on mitigation policies

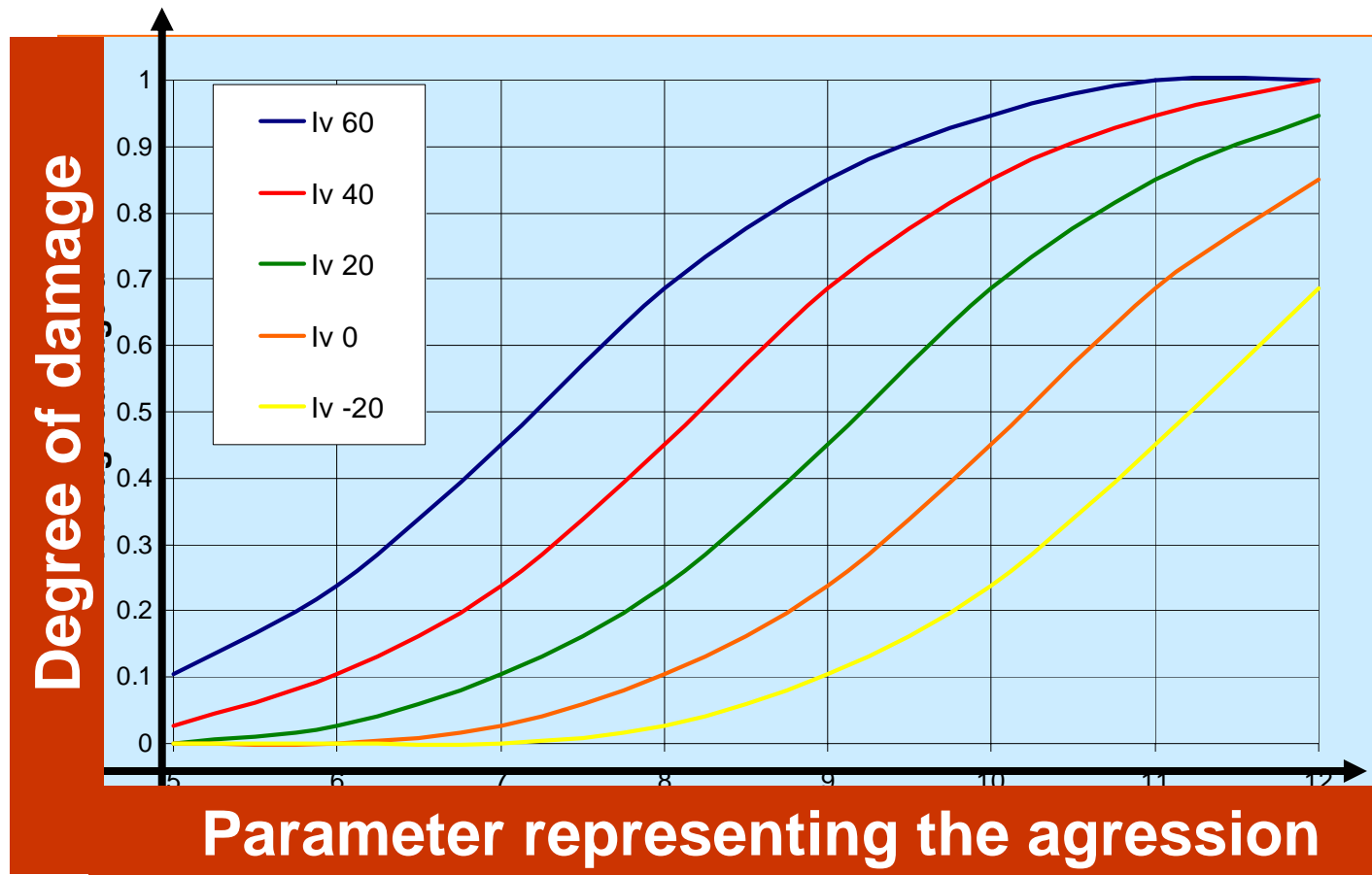


Policies focusing on crisis finally save lives, but recovery costs continue to increase

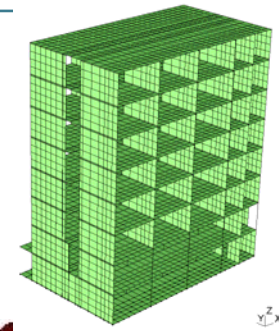
Mitigation policies:

- reduce vulnerability of exposed elements, saving lives and costs
- contribute to sustainable use of natural resources

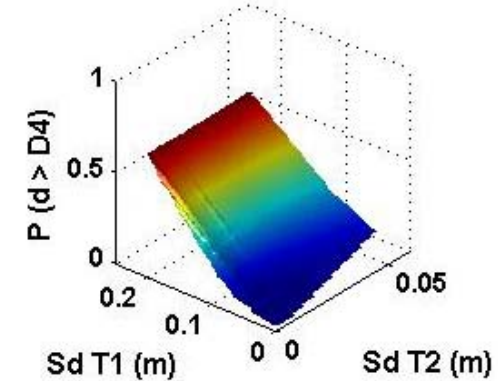
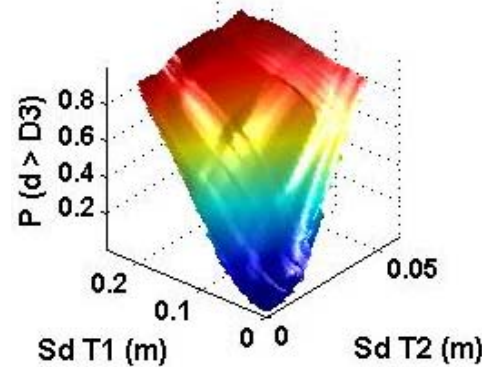
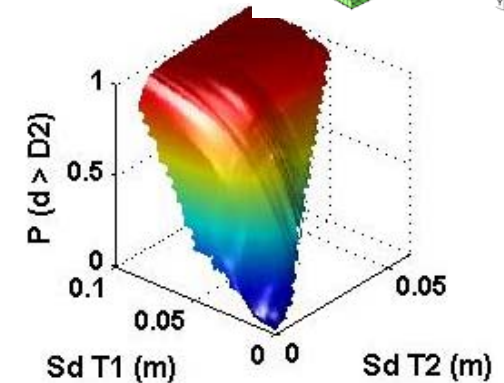
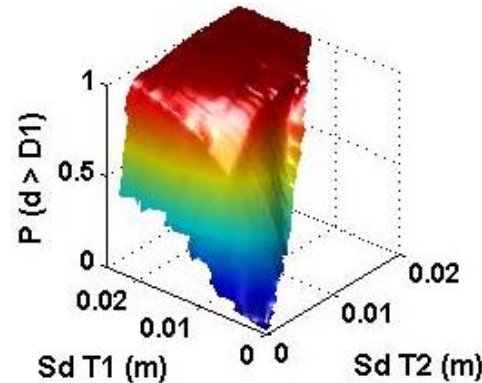
Schematic representation of Vulnerability

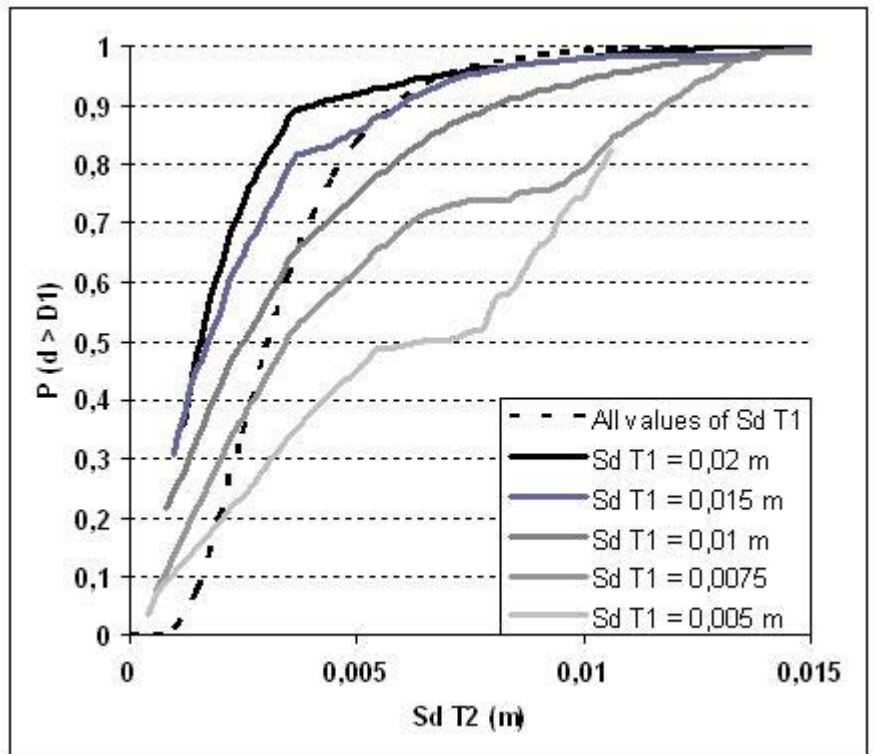
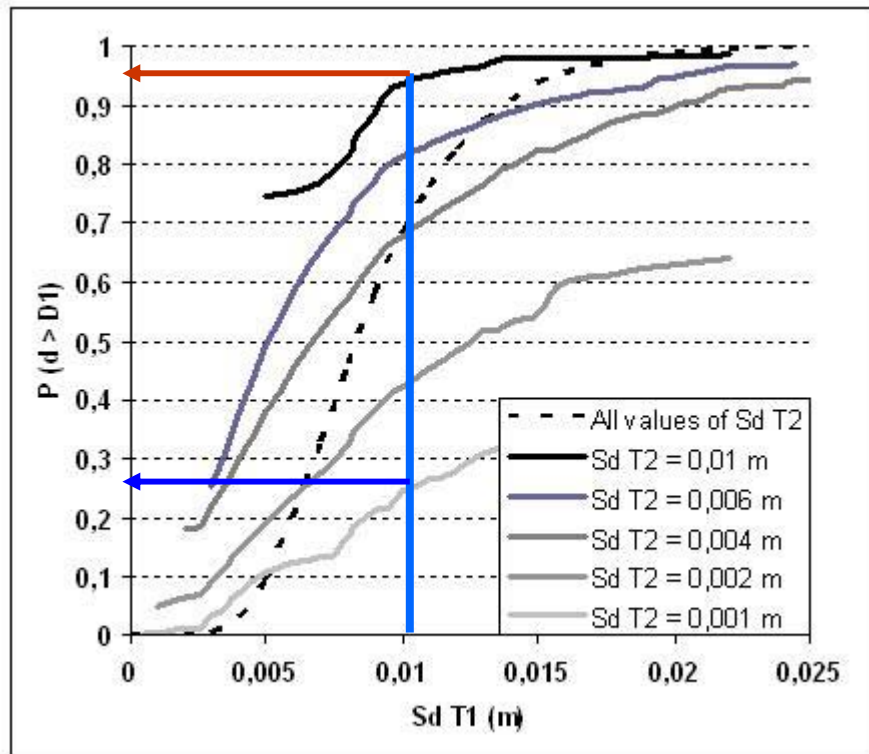


Fragility Curves vs Fragility Surfaces



Fragility surfaces of the studied building for four damage levels (based on EMS 98). The parameters are spectral displacements at T1 and T2, the periods corresponding to the main eigen-modes of the building in the X direction





Physical Vulnerability : generalization of concepts

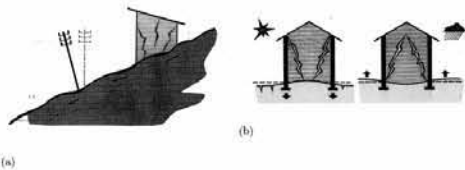
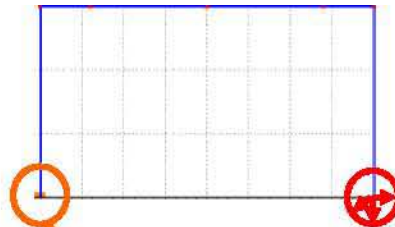


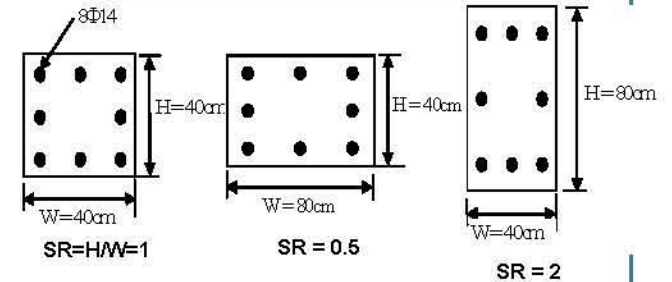
FIG. 10 - Exemples des tassements différentiels dus aux facteurs externes a) glissement de talus, b) variations climatiques.



Différentes liaisons sol/fondation

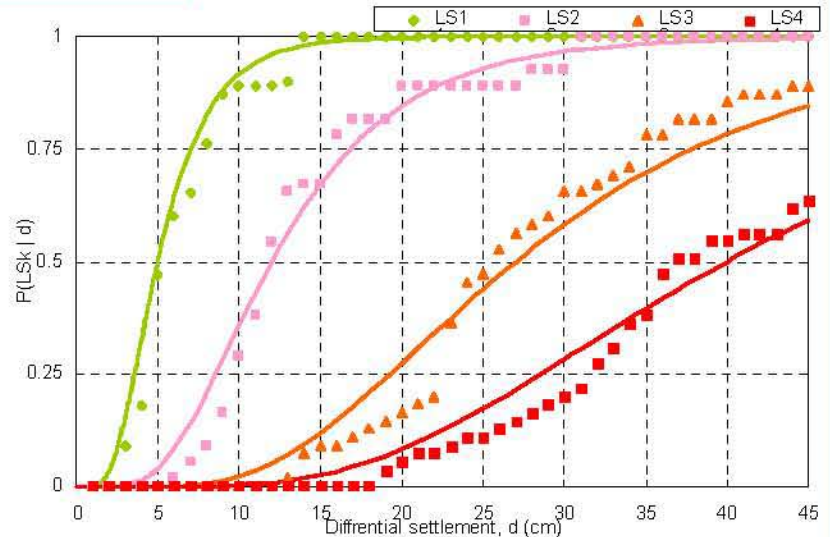
D : Amplitudes & inclinaisons variables

Géométrie et % d'armatures variables



| Niveau de dommage (LS) | Limite élastique ϵ_y | Béton armé (compression) ϵ_{CLS} | Acier (traction) ϵ_{sLS} |
|------------------------|-------------------------------|---|-----------------------------------|
| 1 | 0.2% | - | - |
| 2 | - | 0.4% | 1.5% |
| 3 | - | 0.6% | 4% |
| 4 | - | 1% | 6% |

Ex. dommages : niveau de fissuration, ...



Soil-Structure Interaction

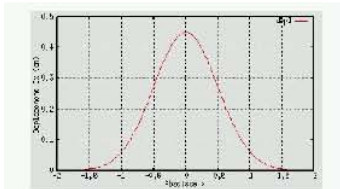
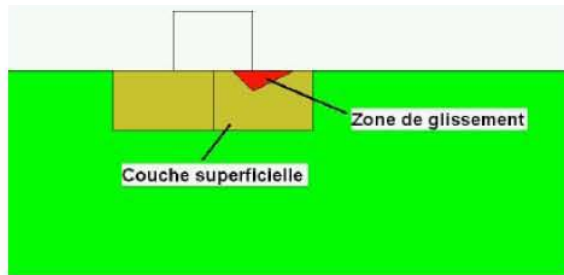


Figure 13 - Variation spatiale du déplacement O_x imposé

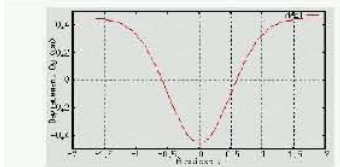
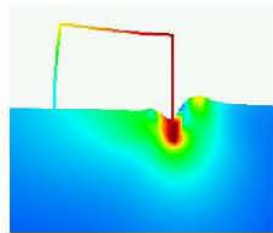


Figure 18 - Variation spatiale du déplacement O_y imposé

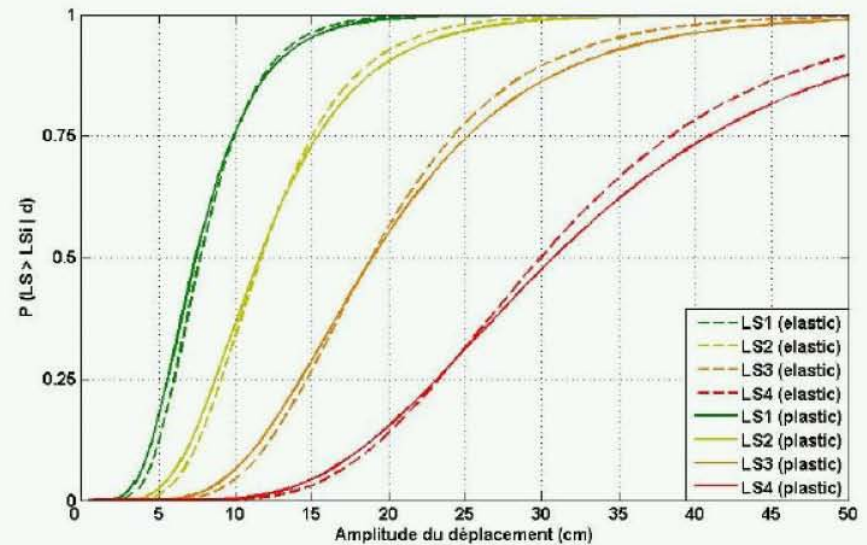
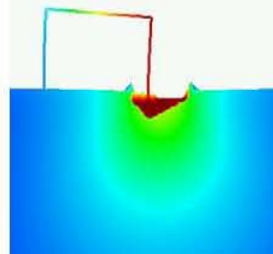
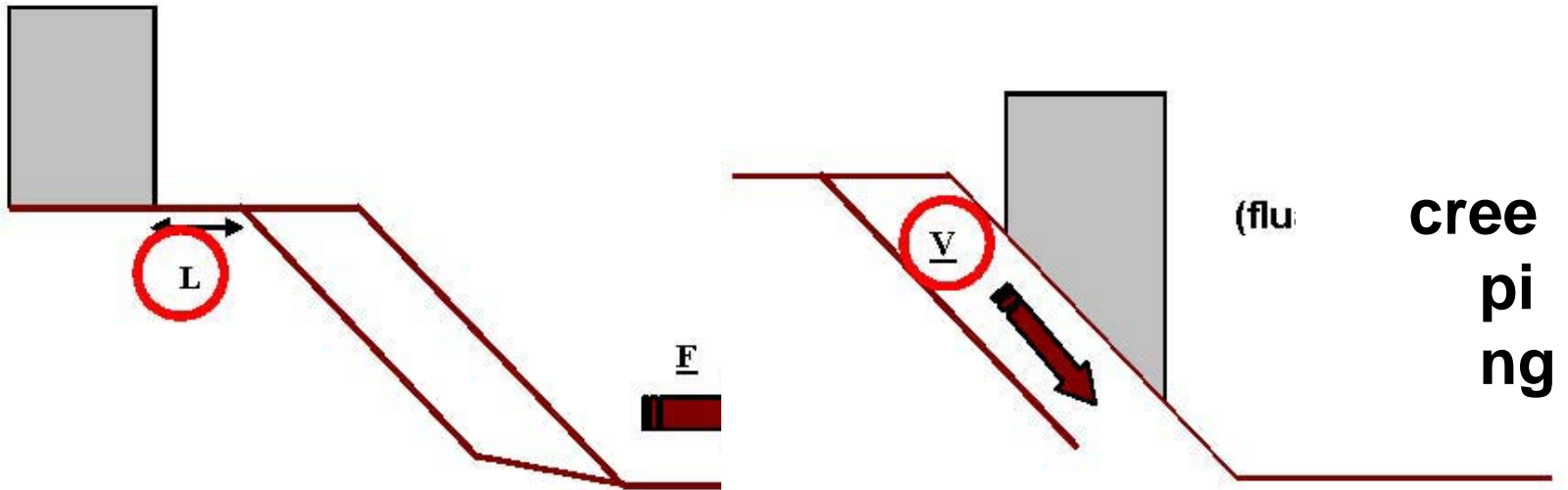
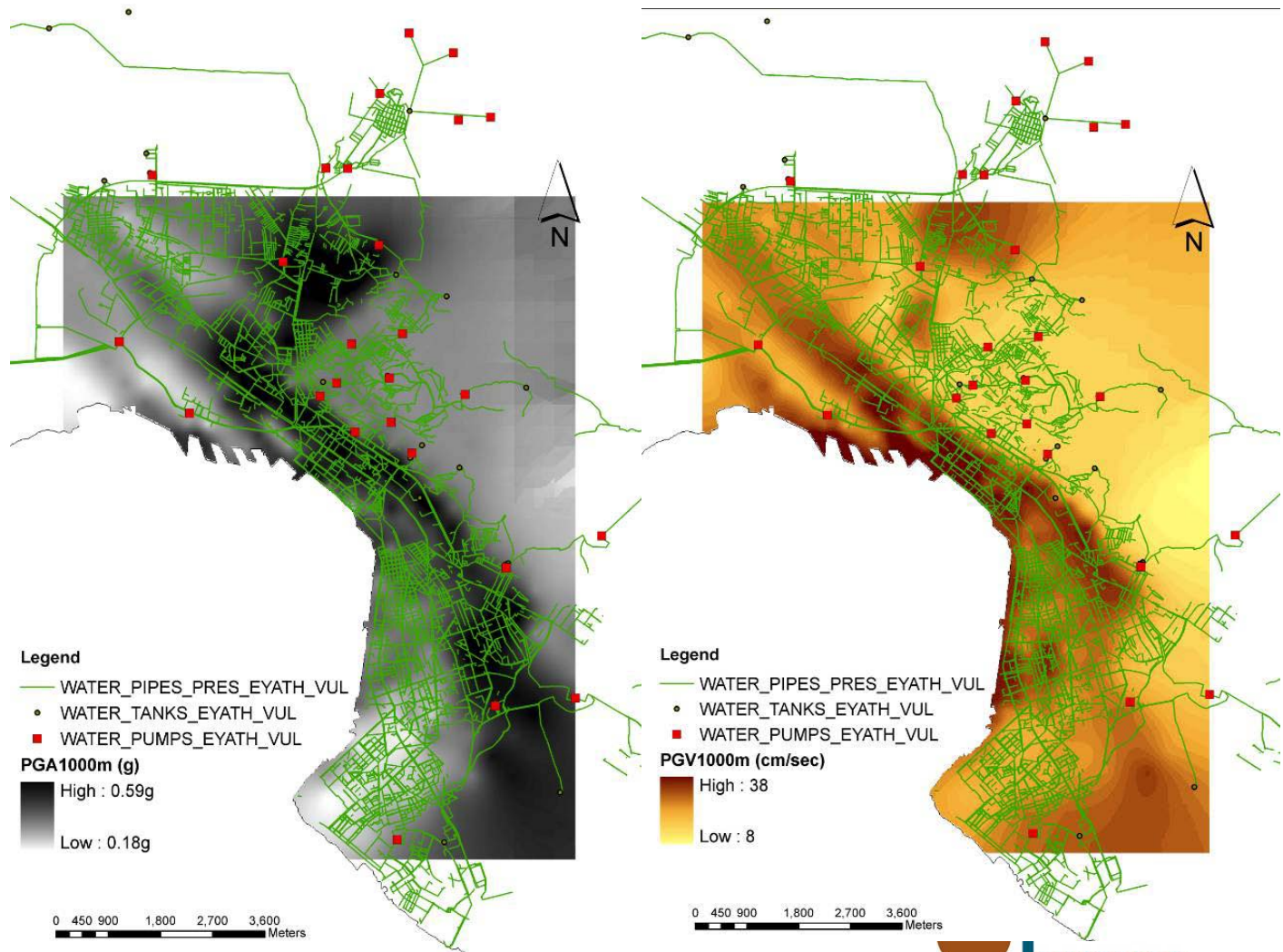


Figure 24 - Courbes de fragilité dans le cas d'un sol "contrasté" (les courbes en pointillés représentent le cas où le sol est considéré comme élastique linéaire, et les courbes pleines prennent en compte la plasticité)

What is the pertinent representative factor?



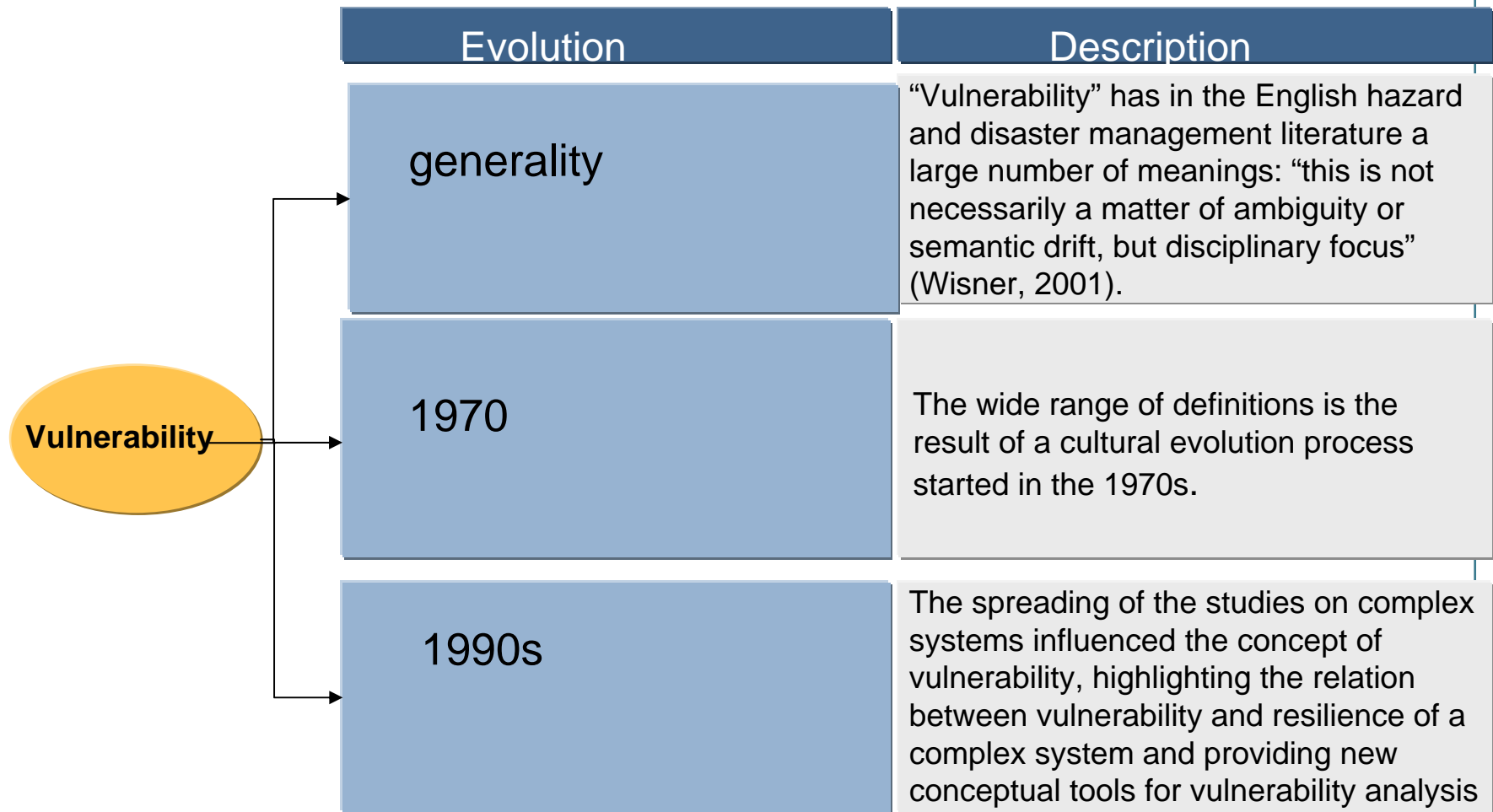
Spatial distribution of PGA (left) and PGV (right) values in Thessaloniki for the seismic scenario of 1000 years



from Pitilakis and co-workers



Definition of Vulnerability



from Margotini *and co-workers*



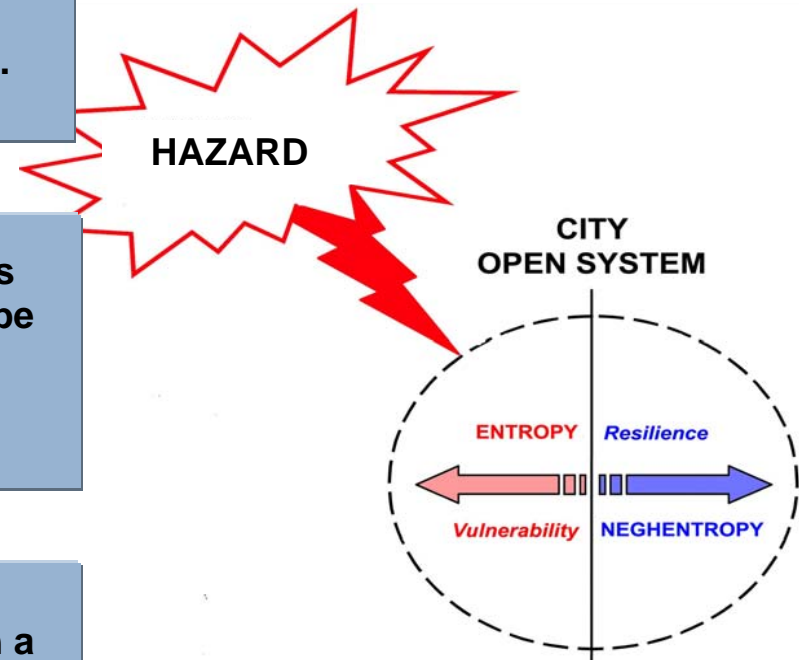
Resilience/Vulnerability

Resilience: “the capacity of a system, community or society, potentially exposed to hazard to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure”

(World Conference on Disaster Reduction, 2005).

The vulnerability of a system is the obverse of its ability to absorb disturbances, which in turn can be considered to be an indication of its resilience
(Fortune and Peters, 1995)

Vulnerability is the flip-side of resilience (...). In a vulnerable system even small changes may be devastating
(Folke, Carpenter et al., 2002)



from Margotini *and co-workers*

Resilience/Vulnerability

The concept of urban resilience/vulnerability is a multidimensional concept, such as the damages due to hazards (Wisner, 2001)



The main components of the resilience of a territorial system




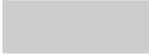
- the resistance of buildings and infrastructures to hazardous events;
- the capacity of the territorial and urban systems to cope with the demand (for activities and services) of the people after an hazardous event;
- the organizational capacity of institutional bodies to face the event and to recover from its impacts;
- the economic and cultural development of the hit systems.

Vulnerability assessment in spatial planning

Levels of deepening of vulnerability analyses in plans and studies

| Type of vulnerability | Earthquake | | | Volcano | | | Floods and Landslides | | | Technological accident | |
|---------------------------------|------------------------------------|---|--|------------------|----------------------------------|----------------------------|------------------------------------|--------------------------------------|----------------------------|------------------------|--------------|
| | Regional | Urban | Local detailed | Regional | Urban | Local detailed | Regional | Urban | Local detailed | Regional | Urban/Local |
| Physical vulnerability | Building stock | Buildings, infrastructures | Buildings, infrastructures, aggregates | Type of land-use | Type of land-use, Building stock | Buildings, infrastructures | Type of land-use | Land-use, Buildings, infrastructures | Buildings, infrastructures | Population | Population |
| Plans | Orange | Yellow | Orange | Yellow | Yellow | Grey | Yellow | Yellow | Grey | Grey | Orange |
| Studies | Orange | Red | Red | Yellow | Orange | Orange | Yellow | Orange | Orange | Grey | Orange |
| Functional Vulnerability | Emergency facilities, road network | Demand/supply for activities, urban pattern, emergency facilities | Urban activities | Road network | Urban activities | Urban activities | Emergency facilities, road network | Emergency facilities, road network | | Road network | Road network |
| Plans | Yellow | Grey | Orange | Yellow | Grey | Grey | Yellow | Grey | Grey | Orange | Yellow |
| Studies | Orange | Red | Red | Yellow | Yellow | Yellow | Yellow | Yellow | Grey | Orange | Yellow |


from Margotini *and co-workers*

| | | |
|--|---|---------------------------|
|  | Studies Topic well defined with methodologies tested on several contexts | Plans Topic full faced |
|  | Topic defined with methodologies not well tested on several contexts | Topic partially faced |
|  | Topic faced without in depth methodologies | Topic just mentioned |
|  | Topic not studied | Topic not considered |

vulnerability analyses are very few and often unsatisfactory

International Disaster Reduction Conference, Davos, August 2008

Vulnerability assessment for risk mitigation planning strategies: *regional scale*

| | Concept | Description |
|--|--------------------------|--|
|  | Physical vulnerability | Analyses on physical vulnerability of strategic elements: lifelines, industries, public equipments, etc. Analyses on building stock vulnerability based on “indirect” data such as building age, site occupancy indexes, social conditions of population, illegal building concentration, and so on. |
| | Functional vulnerability | Analyses on location, distribution and load capacity of emergency equipments (hospitals, civil protection, collecting areas, road networks, etc). In-depth analyses on the road networks both for population exodus, rescue team access and access to strategic equipments. |
| | Planning strategies | Guide-lines for the re-location of activities and population Guide-lines for the definition of Emergency Network Priority risk areas identification. In these areas in-depth analyses on physical vulnerability, based on direct data, could be carried out at urban or local scale. |

from Margotini *and co-workers*



Vulnerability assessment for risk mitigation planning strategies: *urban and local scale*

| Concept | Description |
|--------------------------|---|
| Physical vulnerability | Analyses on physical vulnerability of urban tissues, building aggregates and individual buildings. In-depth analyses on physical vulnerability of strategic equipments. |
| Functional vulnerability | Analyses referred to urban tissues features which, with regard to different hazardous events, can affect the capacity of the city to cope with the demand for activities and services induced by the event (i.e. compactness of urban tissues or irregularity of road networks). Location, distribution and load capacity of emergency equipments, including main road networks. |
| Planning strategies | General rules for urban tissues vulnerability reduction (compatible uses, accessibility, etc.) Local emergency network organization (strategical equipments, road network, open spaces, etc.) Anti-seismic prescriptions for building and aggregate restoration. |

Vulnerability analyses

from Margotini *and co-workers*



Vulnerability assessment

Briefly, even though some examples of vulnerability (physical and functional) analyses at different scales have been carried out in many parts of Europe, they are generally referred to individual hazards (namely to seismic hazard)



Very few vulnerability analyses related to other hazard factors have been set up and they have been generally worked out within specific studies or research projects

From risk to multi-risk analysis: toward and integrated vulnerability assessment

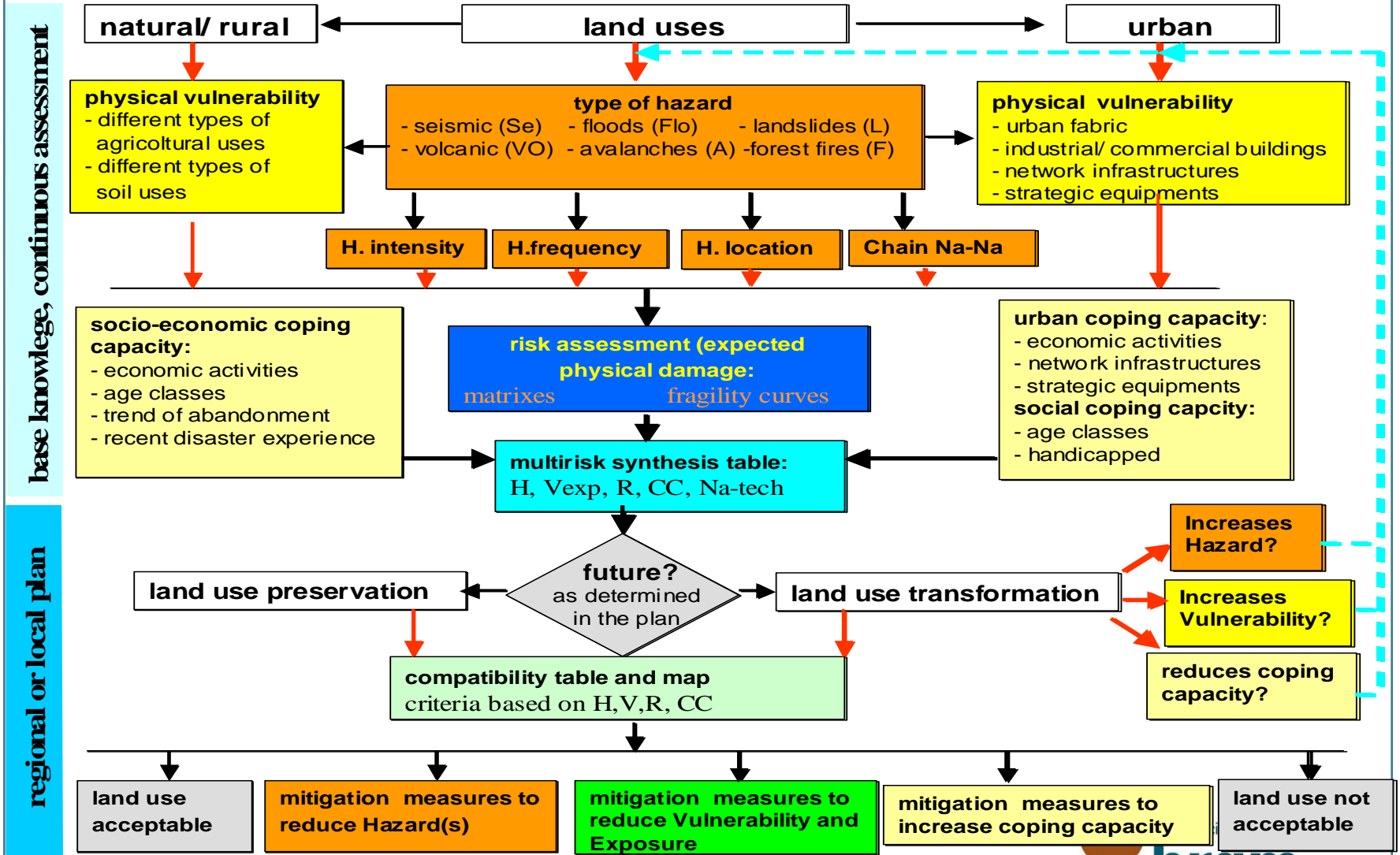
Territorial systems have often to face more than one hazard.
In these cases a multi-risk assessment is required

Nevertheless, the “overlapping” of individual risk maps could be ineffective to describe the complex interactions among the different hazards and their impacts.



Complex hazardous events depend not only on the spatial coincidence of individual hazards which may occur in different times, but even on the interactions among different hazards which occur simultaneously or in strict connection (for instance na-tech disasters or natural disasters made by linked natural hazards)

Vulnerability in practical application



from Margotini and co-workers



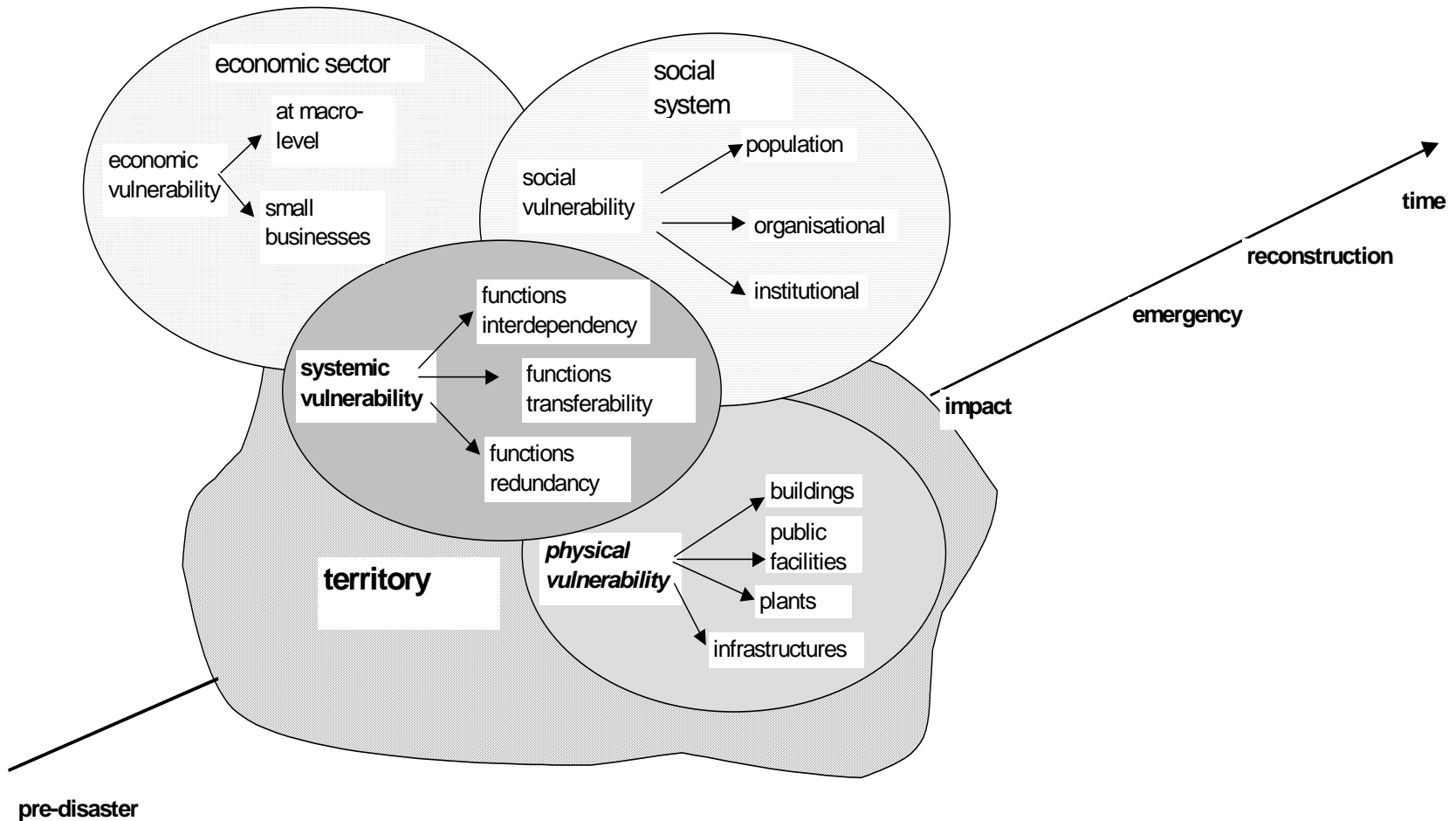
ENSURE

(FP7, juin 2008, 32 mois)

**Enhancing resilience of
communities and territories
facing natural and na-tech
hazards**

Overall Objectives

- > *to develop a new methodological framework for an **Integrated Multi-Scale Vulnerability Assessment**,*



7 main objectives (1/2)

- > Improve the understanding of the articulated nature of the vulnerability concept (physical, economic, cultural, social and systemic), at different spatial scales (regional and local);
- > Analyse the relationship between the vulnerability concept and other notions that are common in the disaster and climate change arenas;
- > Develop integration and connection of vulnerability types;
- > Investigate the temporal and spatial variability of the relation between different types of vulnerability and damage;



7 main objectives (2/2)

- Propose new and improve existing vulnerability assessment models and parameters;
- Develop a comprehensive and structured method that integrates the assessment of different types of vulnerabilities to be tested in three specific case studies;
- Establish improved risk scenarios, based on a new methodological framework

**Thank you
for
your attention**

