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

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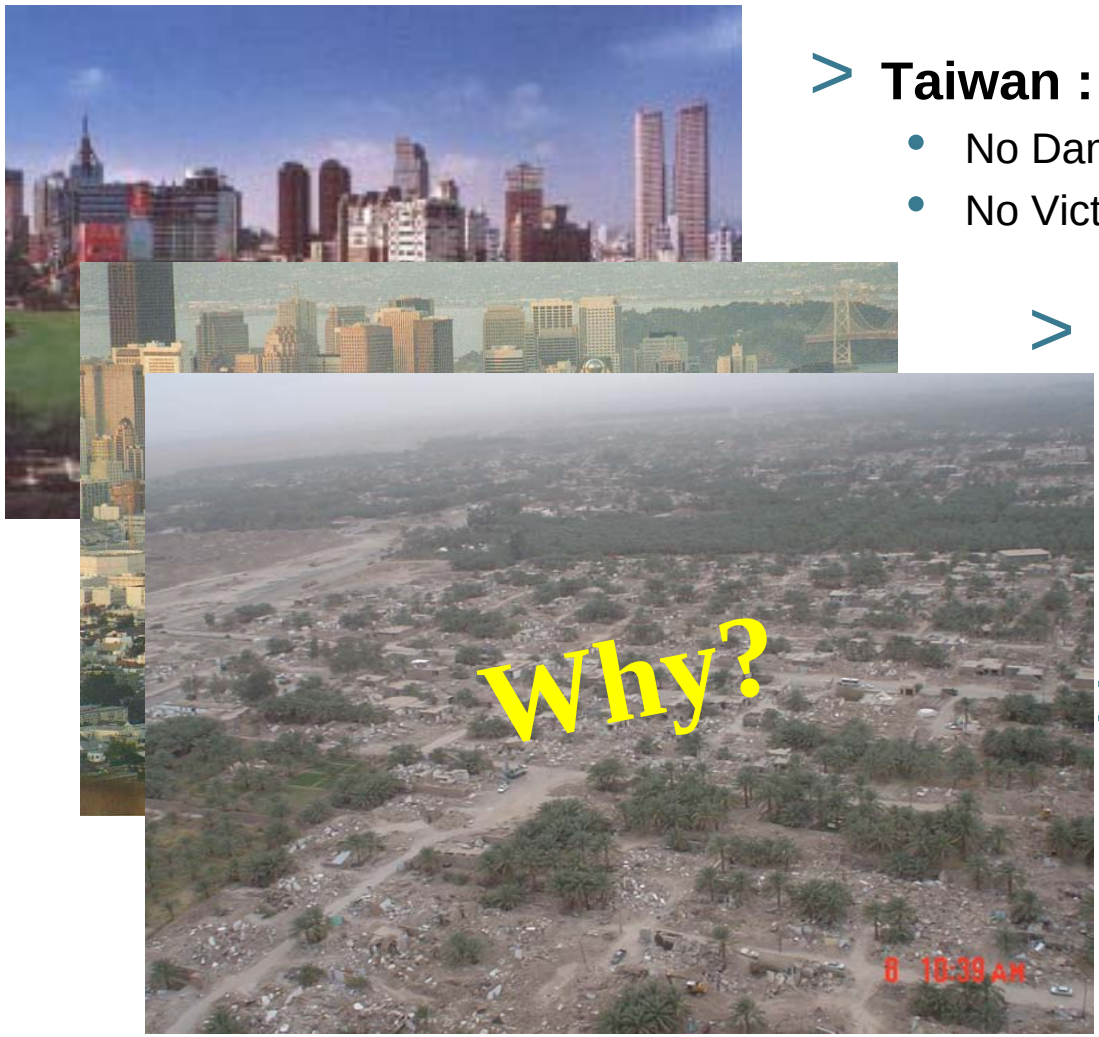
Is vulnerability a major issue ?

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

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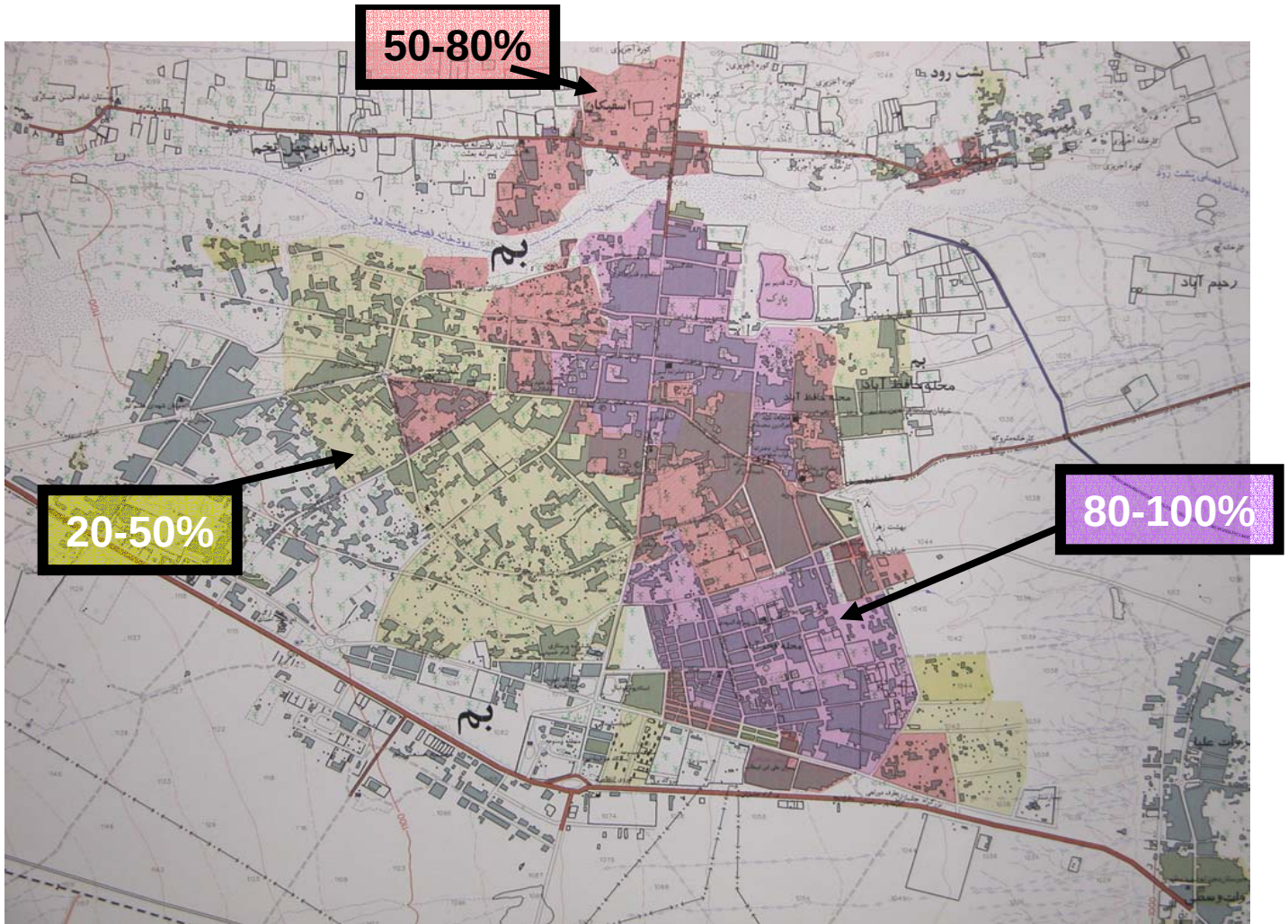
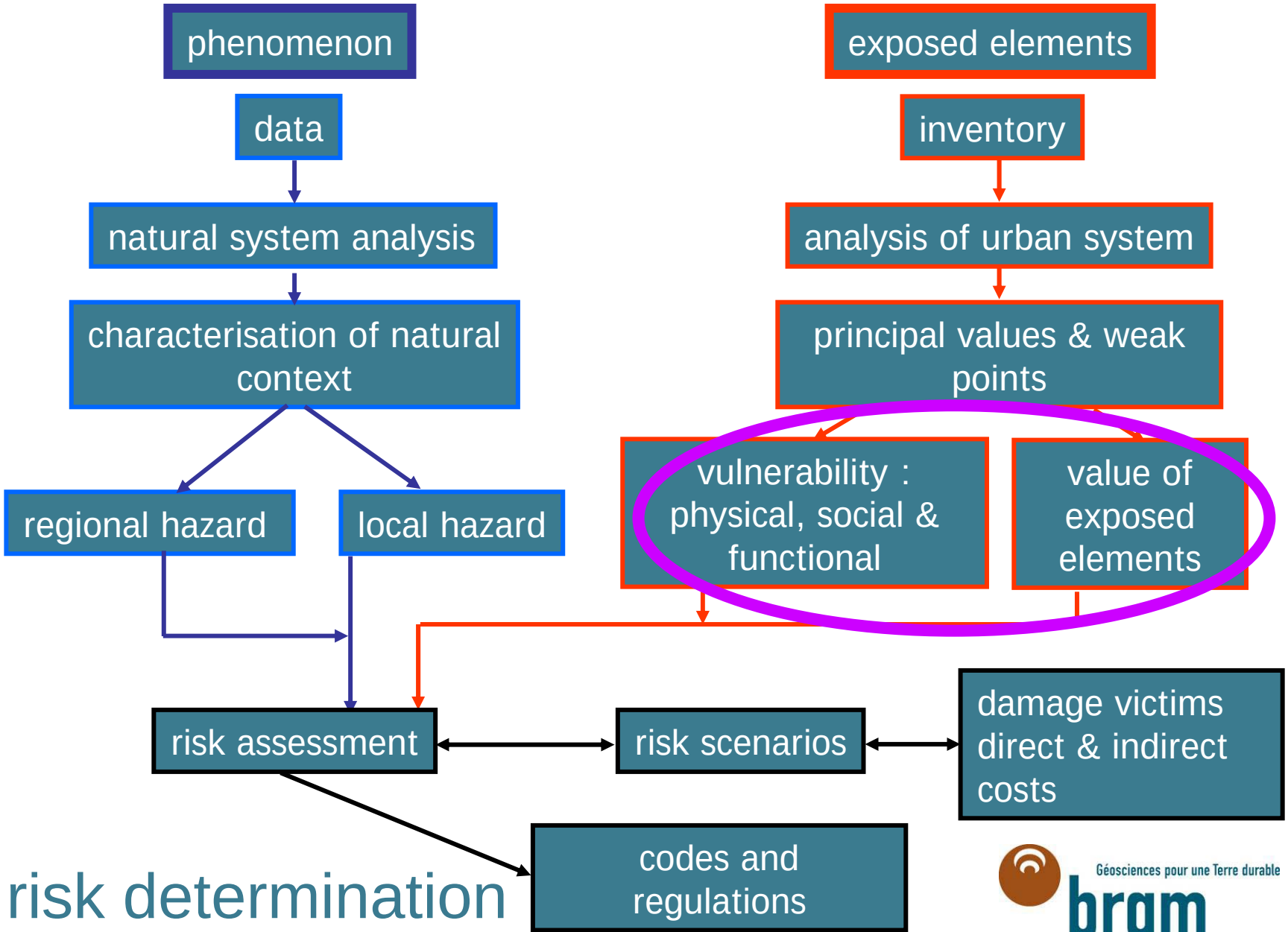
Bam (Iran), December 26, 2003



Destruction %

D'après CGS-IGC

Bam (Iran), 26 décembre 2003


phenomenon
data
natural system analysis
characterisation of natural context
regional hazard
local hazard
exposed elements
inventory
analysis of urban system
principal values & weak points
vulnerability : physical, social & functional
value of exposed elements
risk assessment
risk scenarios
damage victims direct & indirect costs
codes and regulations
risk determination
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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.

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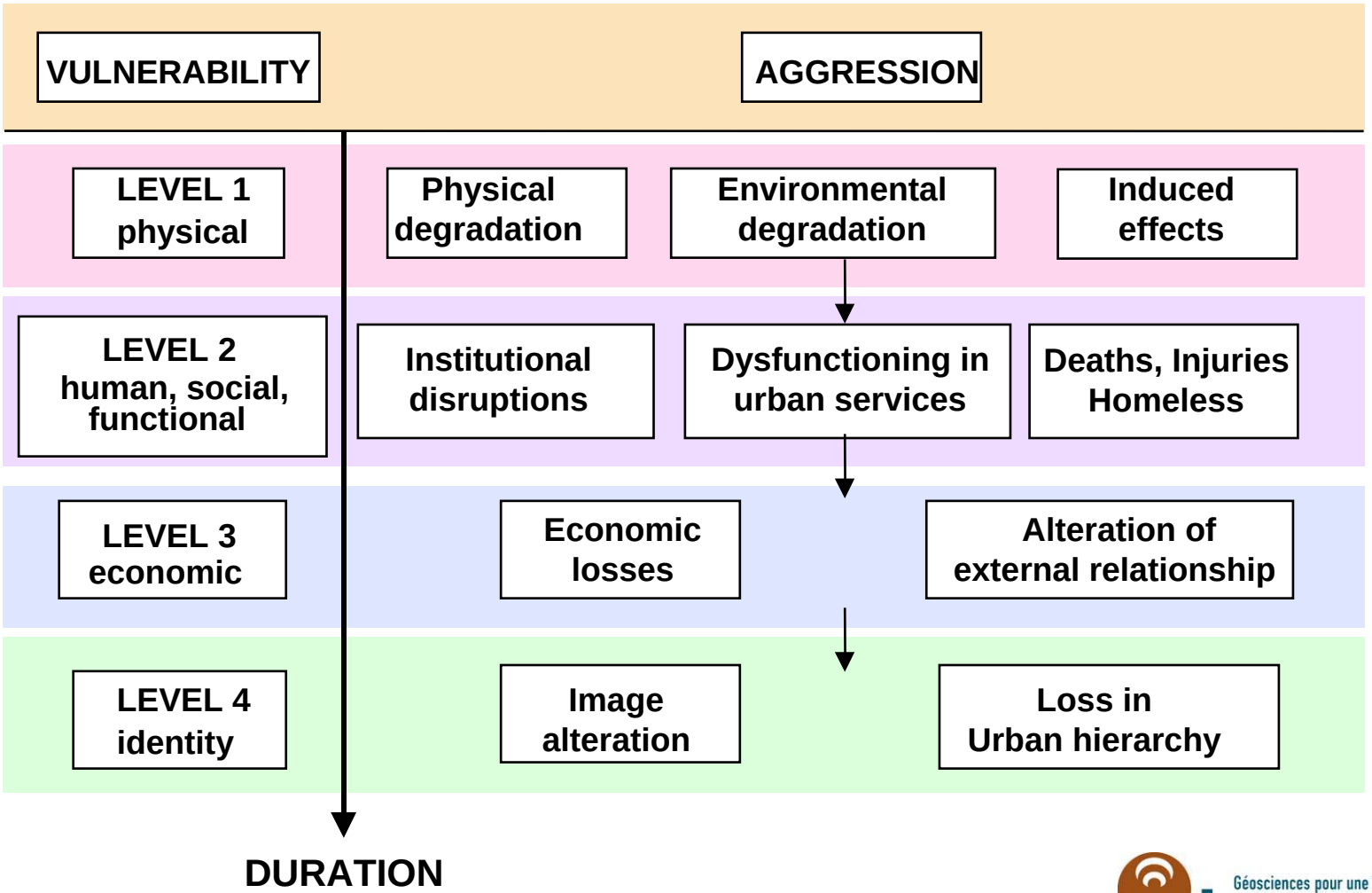
vulnerability levels



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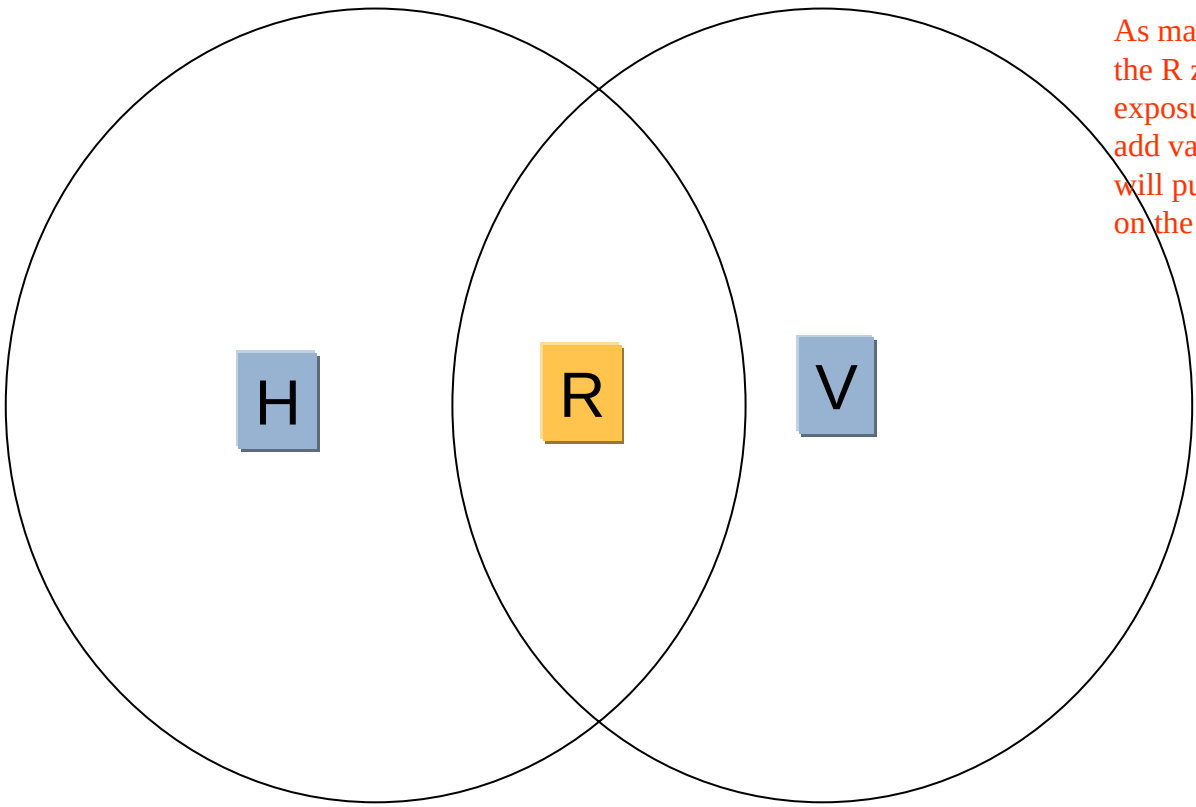
Vulnerability in risk evaluation

Hazard X Exposure X Vulnerability = **Risk**



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.

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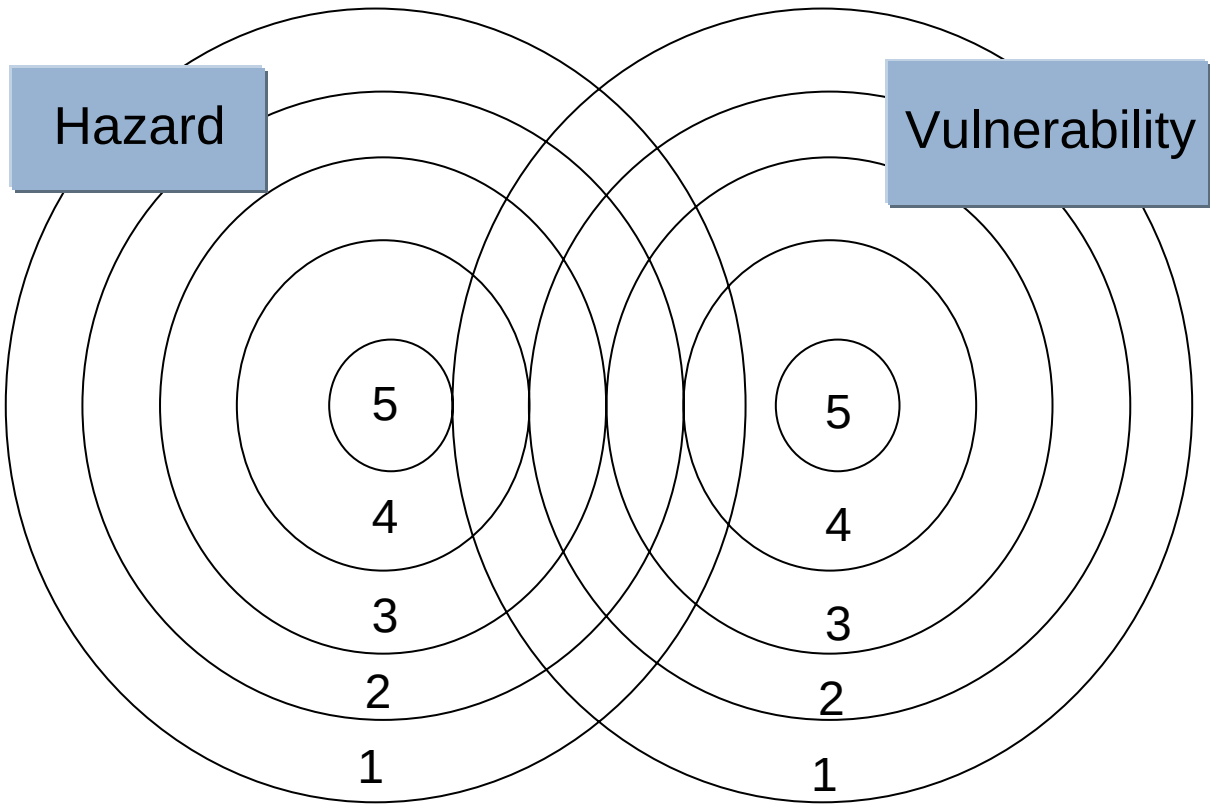
Vulnerability in risk evaluation

Hazard X Exposure X Vulnerability = **Risk**



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Vulnerability in risk evaluation

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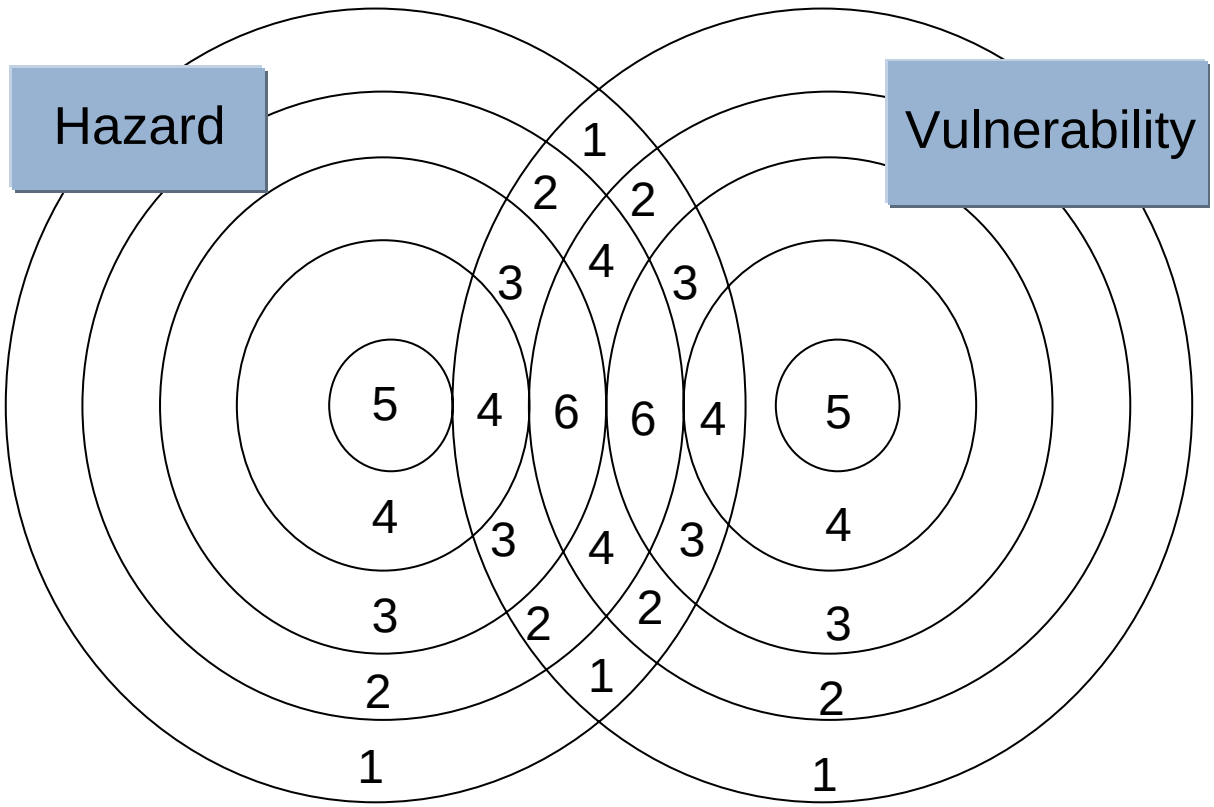

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Vulnerability in risk evaluation

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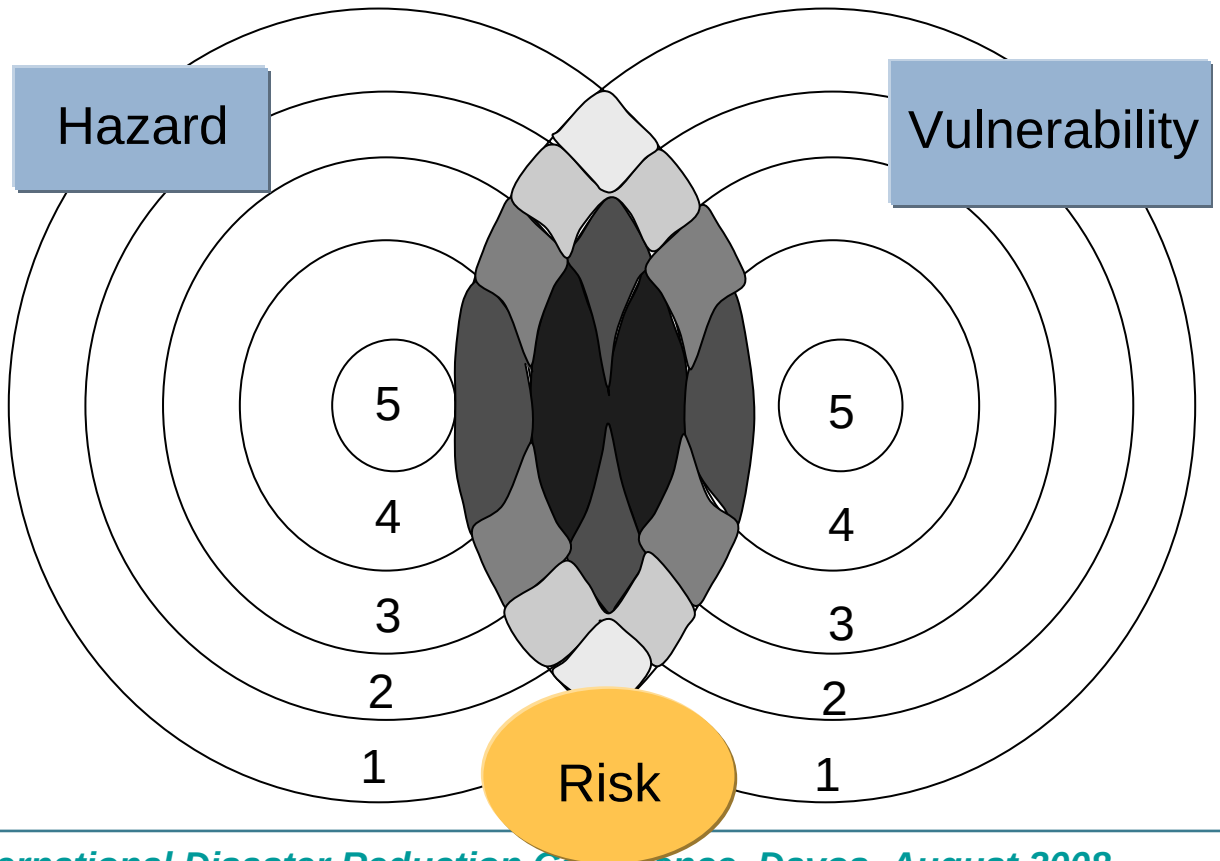

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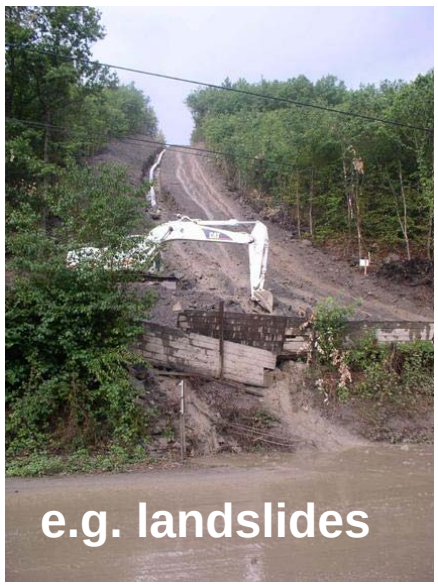
Risk Reduction

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

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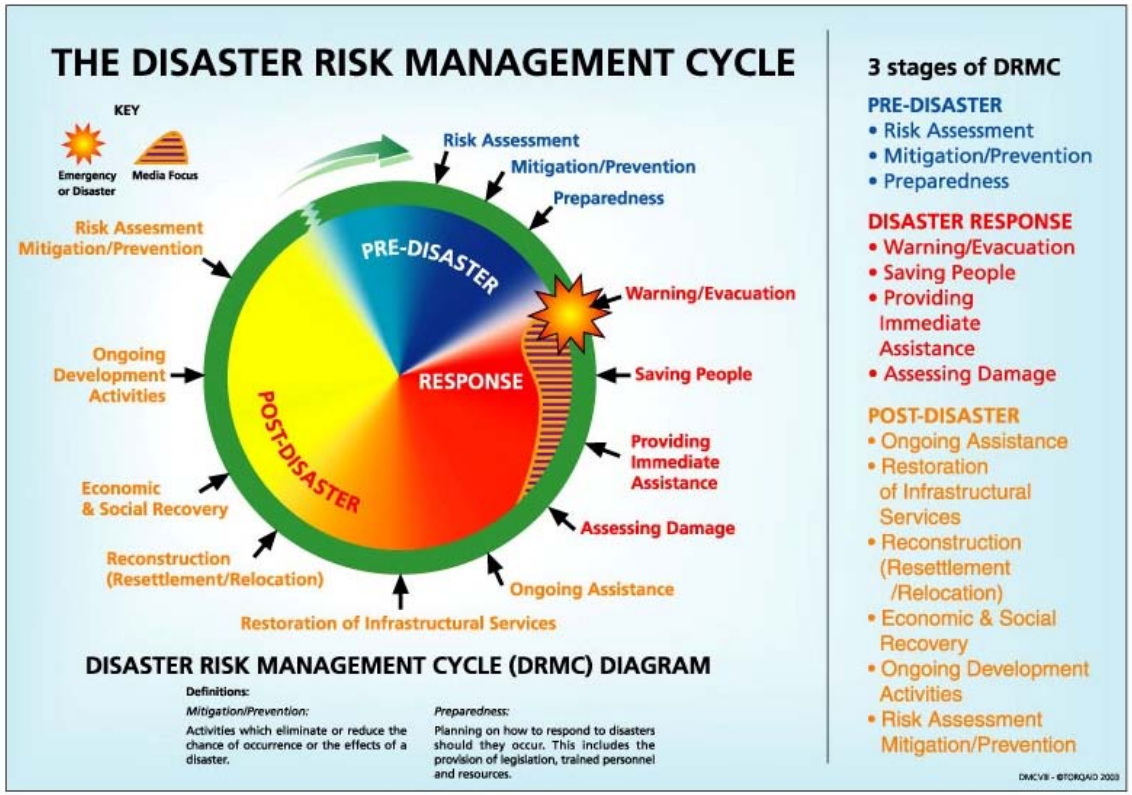
Focus on mitigation policies



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

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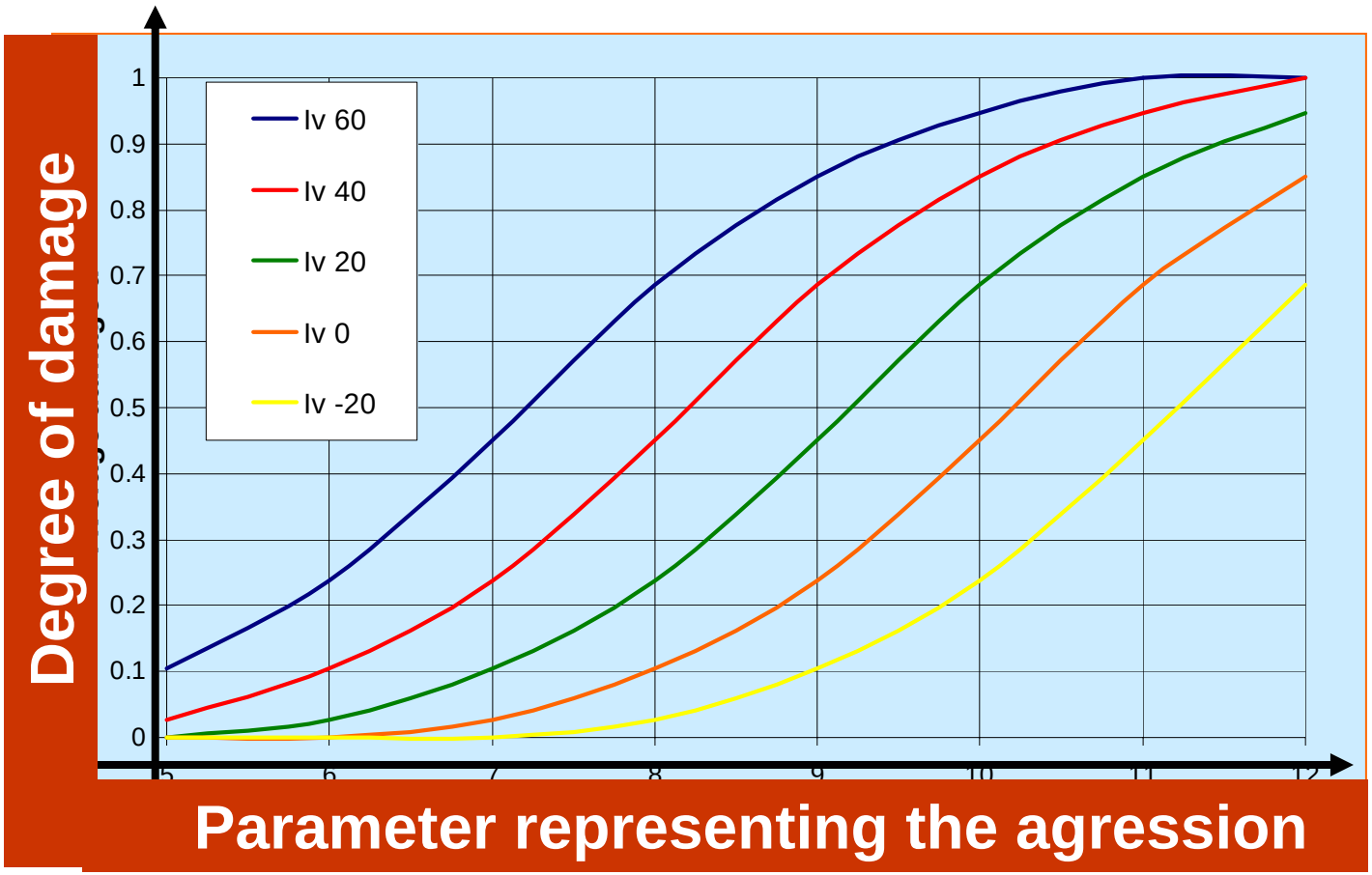
Schematic representation of Vulnerability



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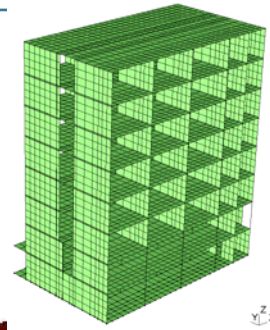
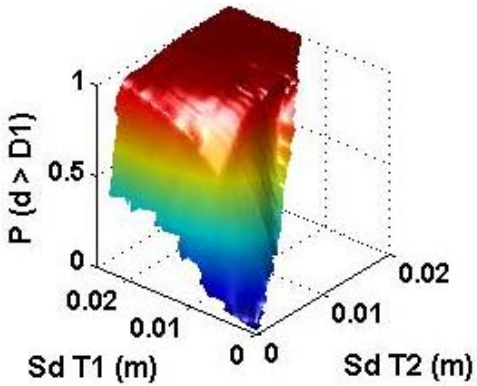
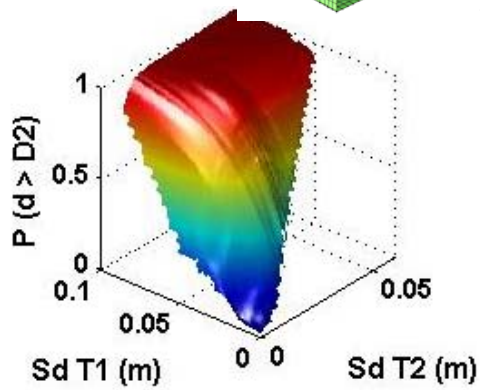
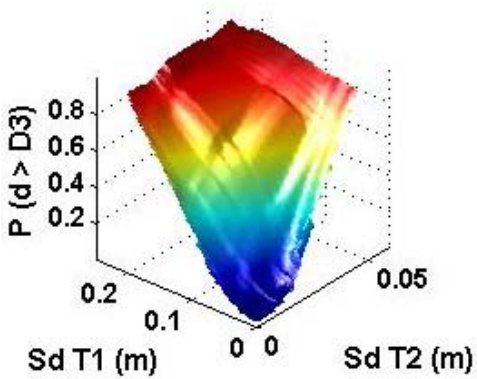
Fragility Curves *vs* Fragility Surfaces

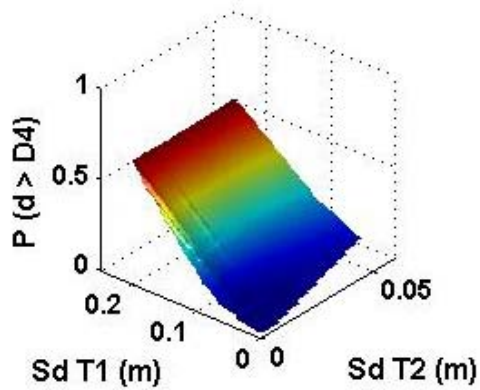


Fragility surfaces of the studied building for four damage levels (based on EMS 98). The parameters are spectral displacements at T1 and T2, the periods corresponding to the main eigen-modes of the building in the X direction









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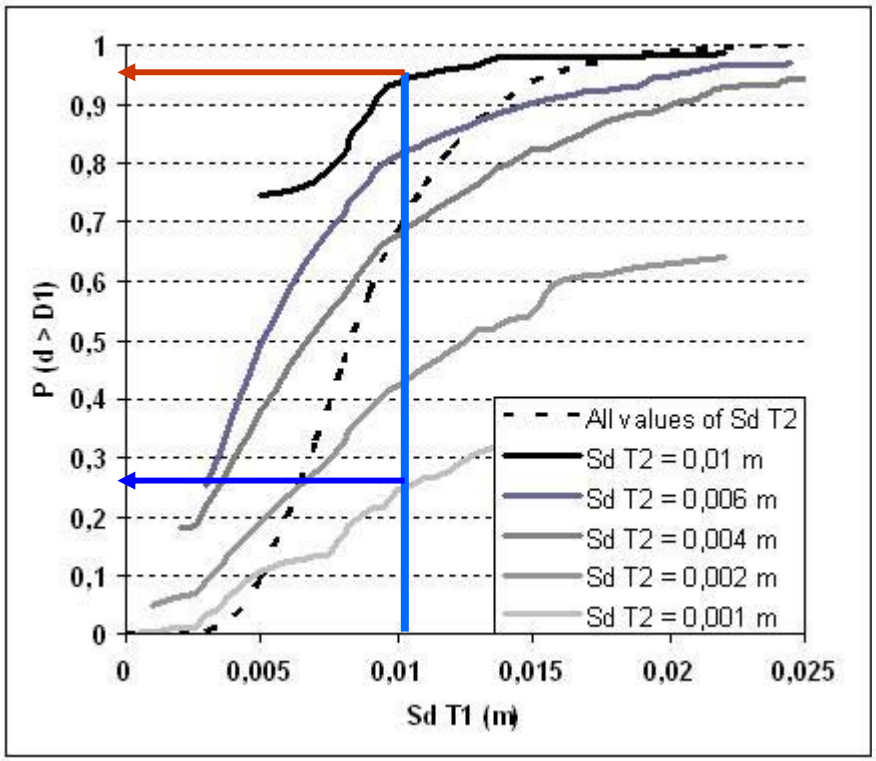

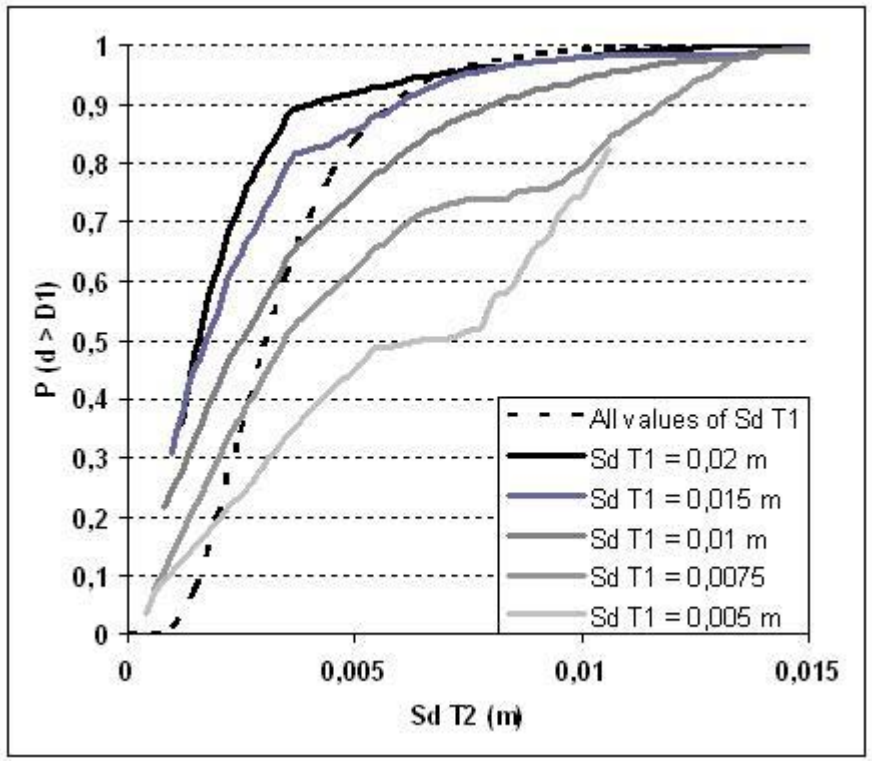

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Physical Vulnerability : generalization of concepts

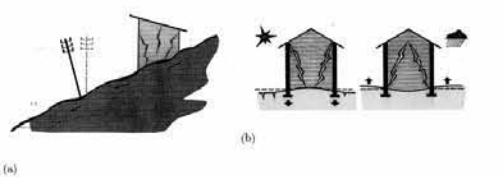
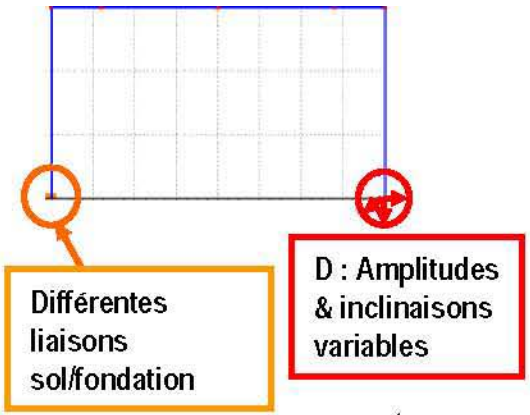
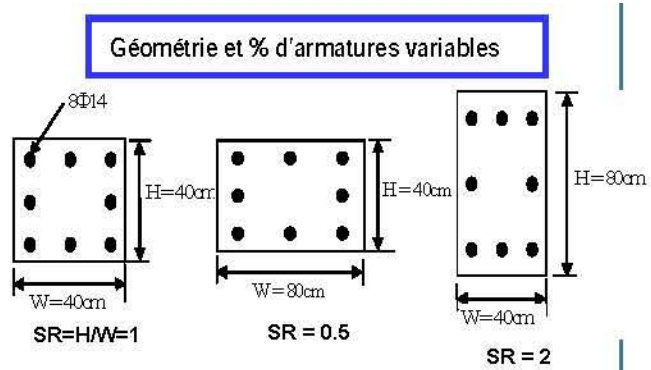


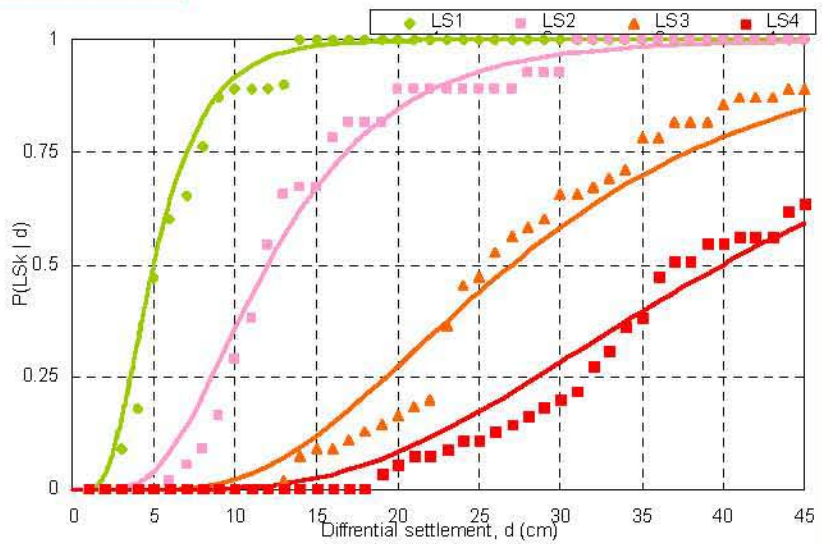
FIG. 10 – *Exemples des tassements différentiels dus aux facteurs externes a) glissement de talus, b) variations climatiques.*



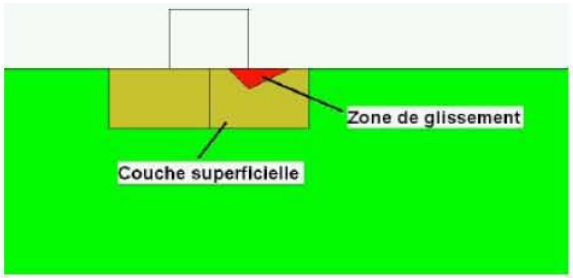


Niveau de dommage (LS)	Limite élastique ε_y	Béton armé (compression) ε_{cLS}	Acier (traction) ε_{sLS}
1	0.2%	-	-
2	-	0.4%	1.5%
3	-	0.6%	4%
4	-	1%	6%

Ex. dommages : niveau de fissuration, …



Soil-Structure Interaction



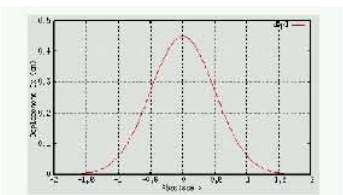
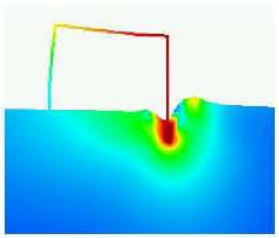


Figure 13 - Variation spatiale du déplacement Ox imposé



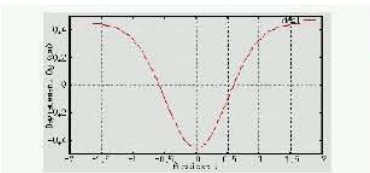
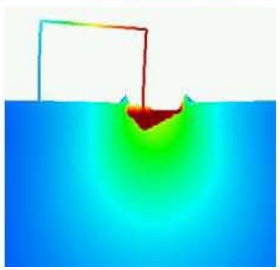


Figure 18 - Variation spatiale du déplacement Oy imposé



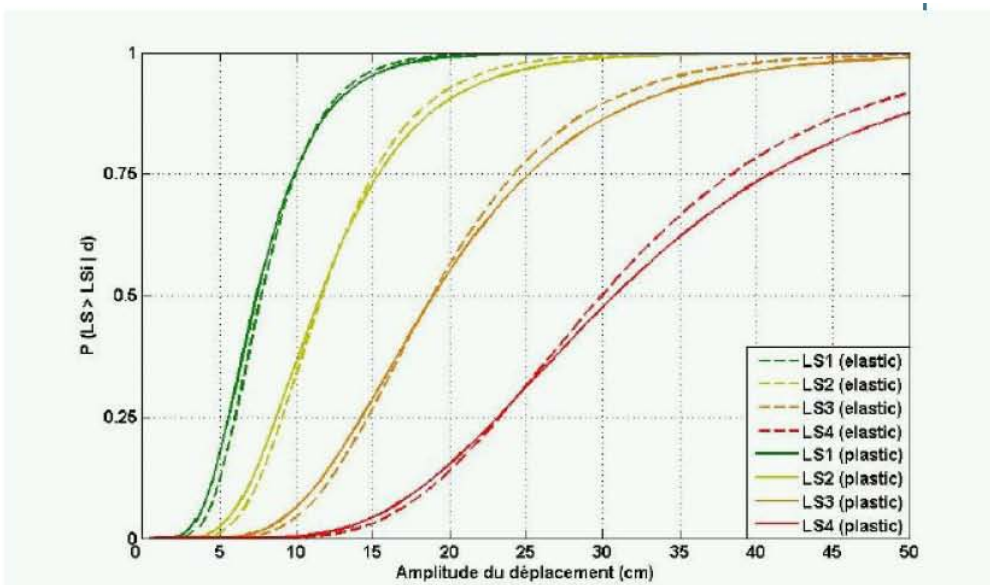


Figure 24 - Courbes de fragilité dans le cas d'un sol "contrasté" (les courbes en pointillés représentent le cas où le sol est considéré comme élastique linéaire, et les courbes pleines prennent en compte la plasticité)

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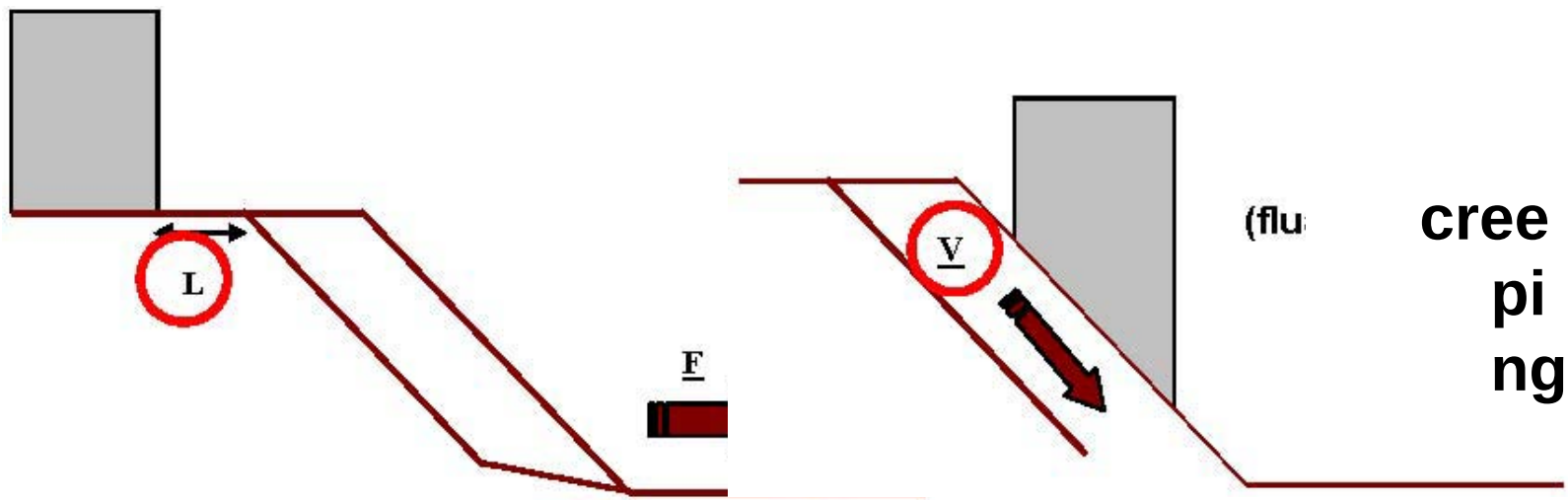
What is the pertinent representative factor?



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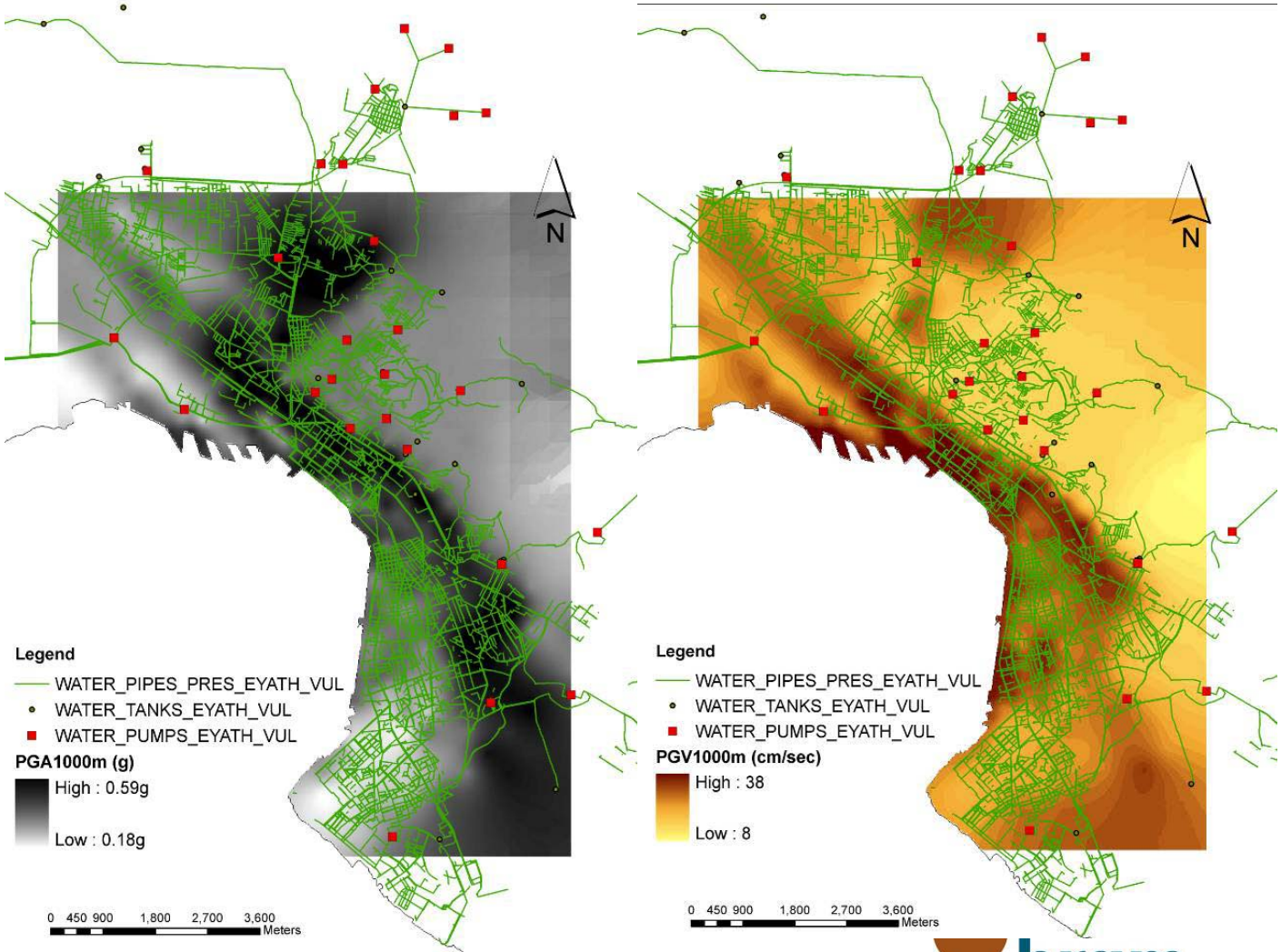
Spatial distribution of PGA (left) and PGV (right) values in Thessaloniki for the seismic scenario of 1000 years



from Pitilakis and co-workers

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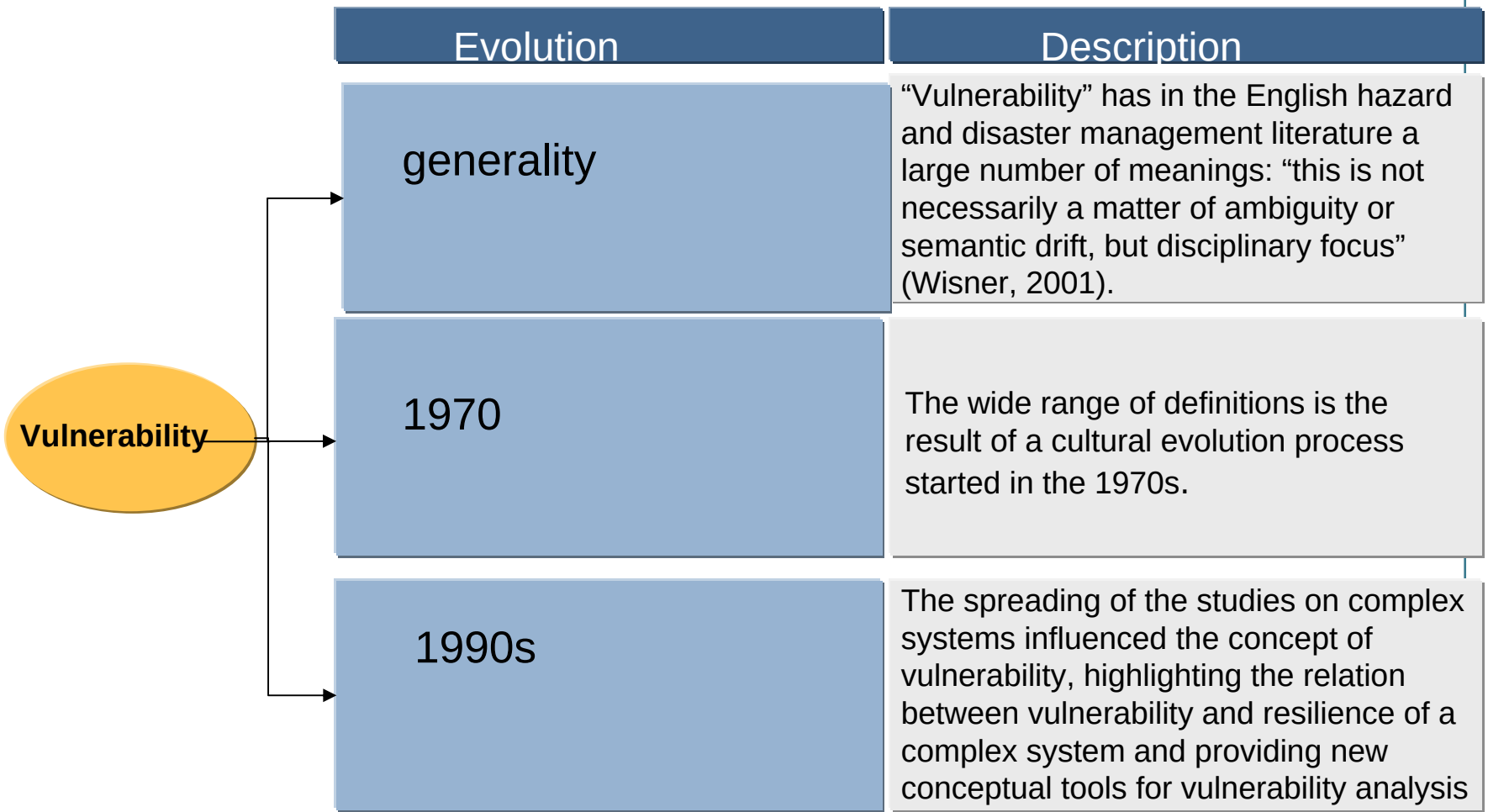
Definition of Vulnerability



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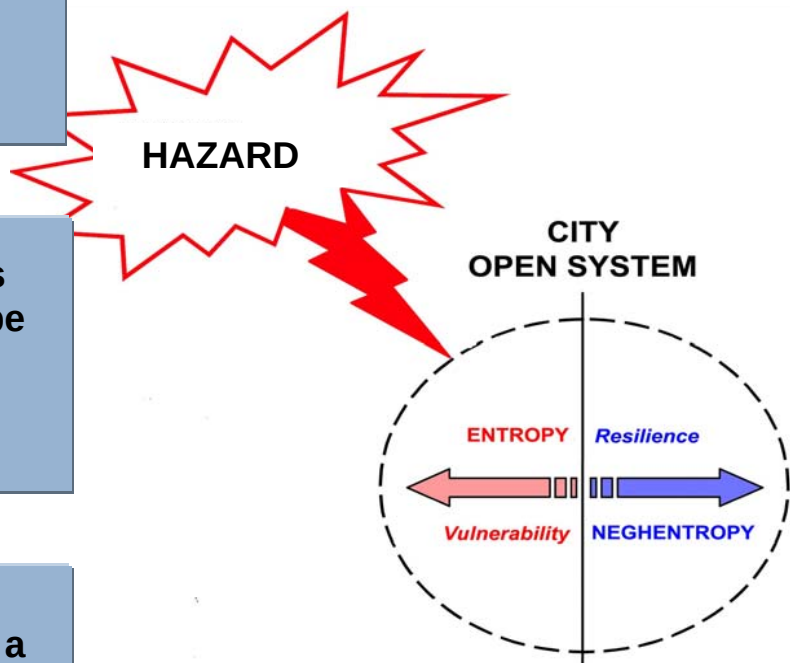
Resilience/Vulnerability

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)



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Resilience/Vulnerabilty

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											
Studies											
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											
Studies											

	Studies	Plans
	Topic well defined with methodologies tested on several contexts	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

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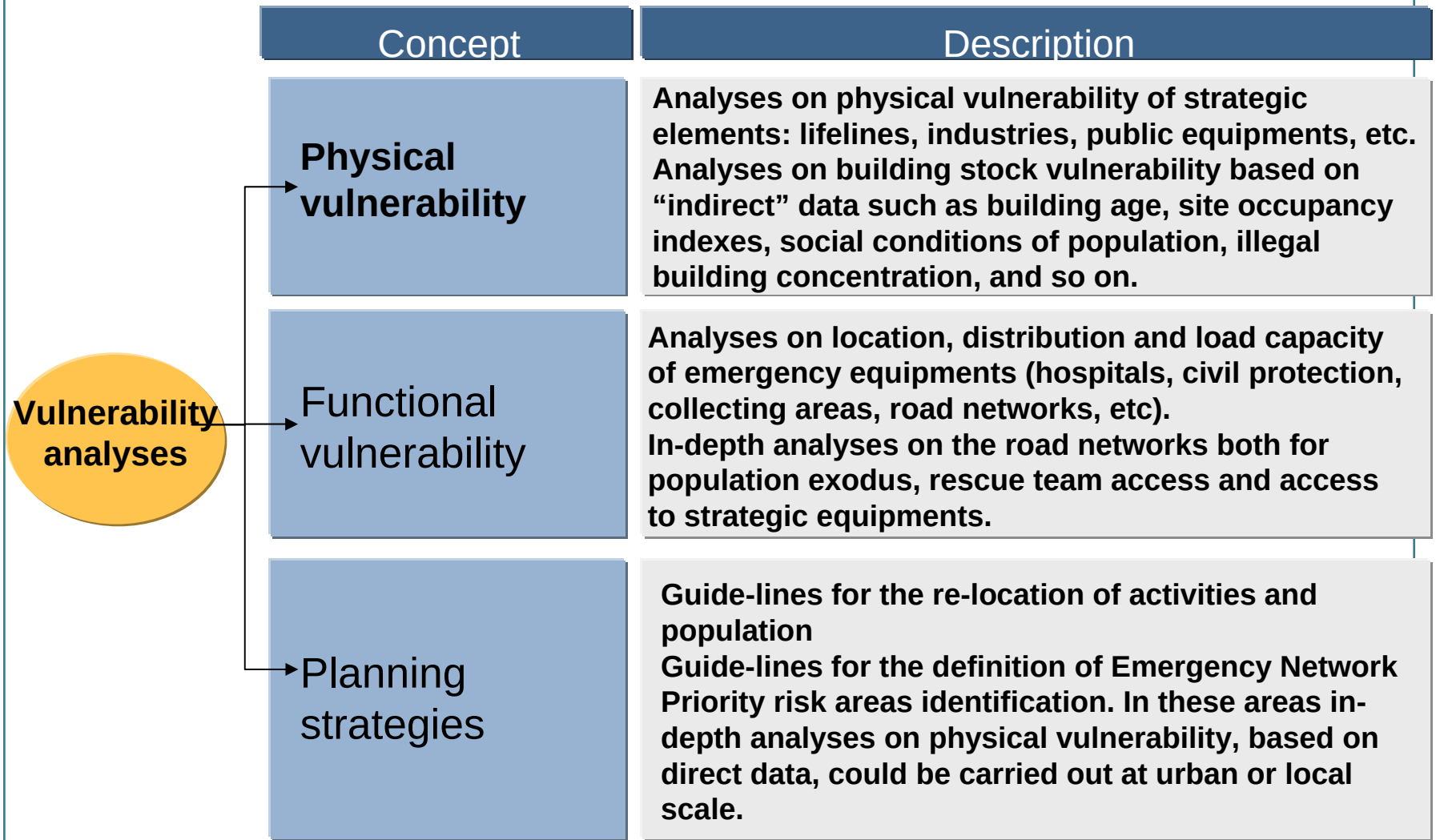
vulnerability analyses are very few and often unsatisfactory

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



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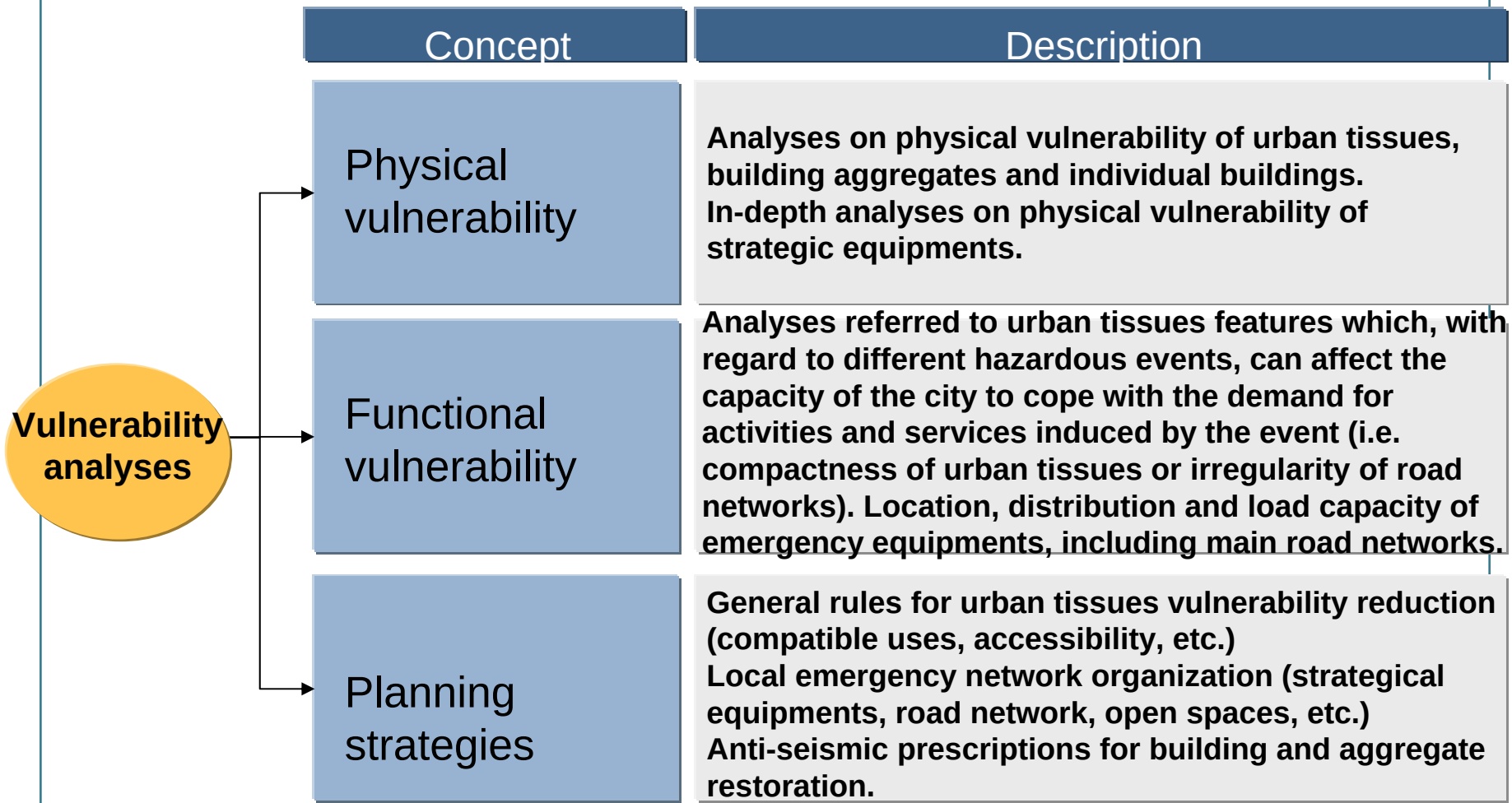
Vulnerability assessment for risk mitigation planning strategies: *urban and local scale*



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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

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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)

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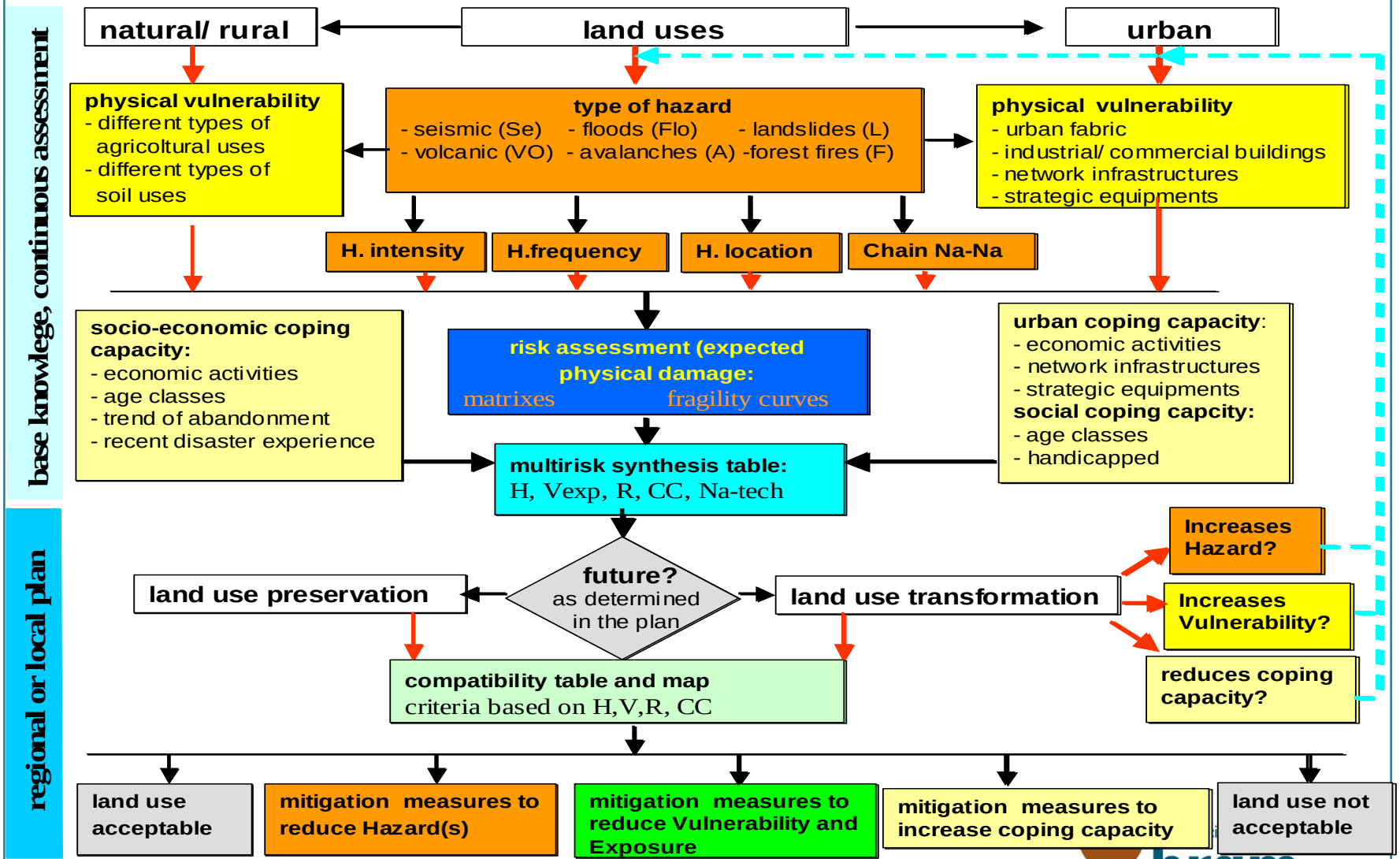
Vulnerability in practical application



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ENSURE

(FP7, juin 2008, 32 mois)

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

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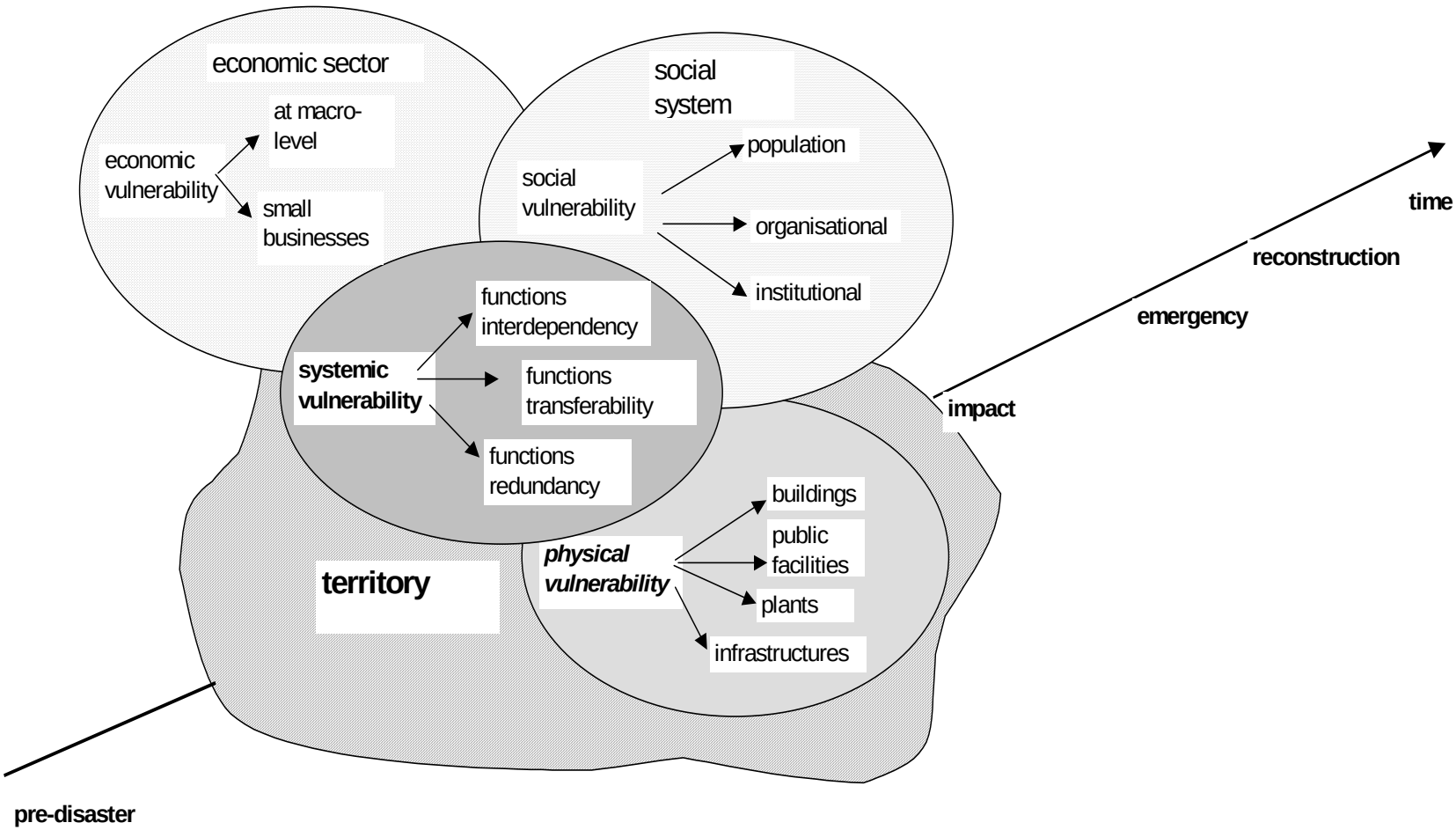
Overall Objectives

> ***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;

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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

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Thank you

for

your attention

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