La mutua interazione fra rischi antropici e rischi naturali. NaTech e resilienza dei territori: strumenti e metodi

Micaela Demichela, David Castro Rodriguez

SAfeR – Sicurezza Affidabilità e Rischi

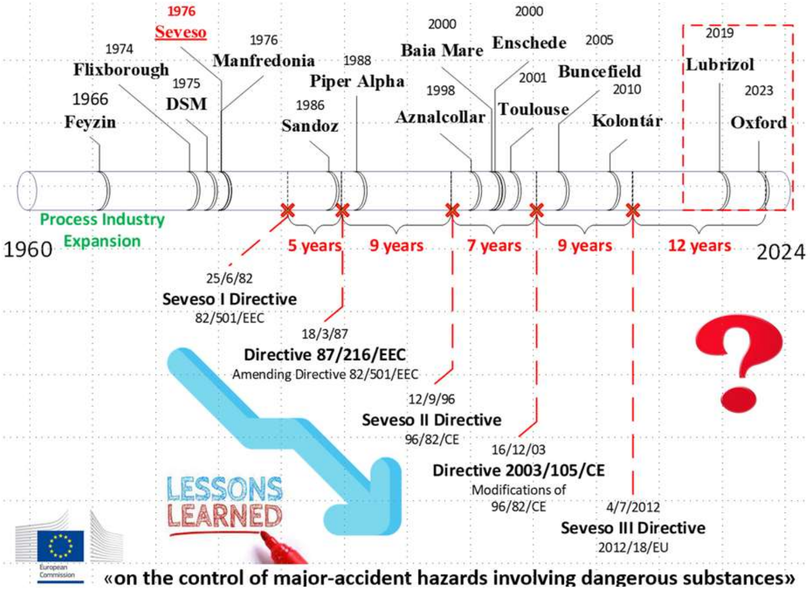
micaela.demichela@polito.it; david.castro@polito.it

Limitations and challenges in the Seveso III : State-of-the-Art















- Although Seveso III Directive (2012/18/EU) serves as a benchmark for industrial plants in Europe and globally, some recognized limitations are present:

GAPS

- The uncertainties involved in complex systems are not well addressed.
- The temporal variability of the hazards and the system gradual degradation are just cited, but analysed separately.
- Limited scope of hazard identification.
- Regulatory uncertainties in risk prevention study validation.
- Underestimation of High-Impact Low-Probability (HILP) Scenarios.
- Frequent disconnection between technical and social or territorial factors.
- Reporting criteria match non-Seveso facilities.
- Differences in legal, geographical, and cultural contexts for transposing the 2012/18/EU Directive to the Member States.

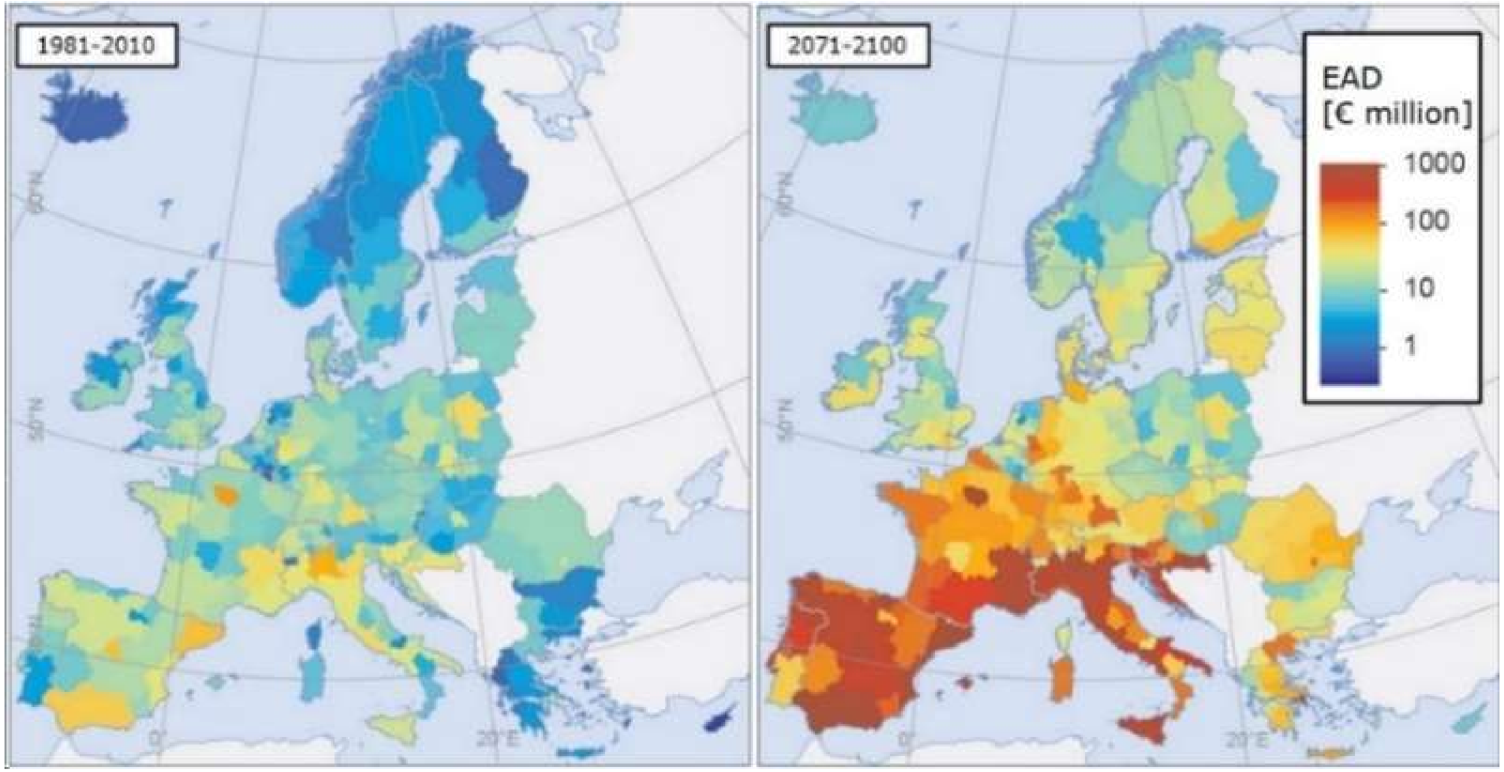
Foreseen scenarios for the Climate Change impacts on CI

Sendai Framework
for Disaster Risk Reduction
2015 - 2030

EU strategy to make Europe more resilient to Multiple Climate Hazards (Multi-hazards) affecting the same territory.

<u>Expected annual damage to critical infrastructure (Stoerk et al., 2018).</u>

European
Commission

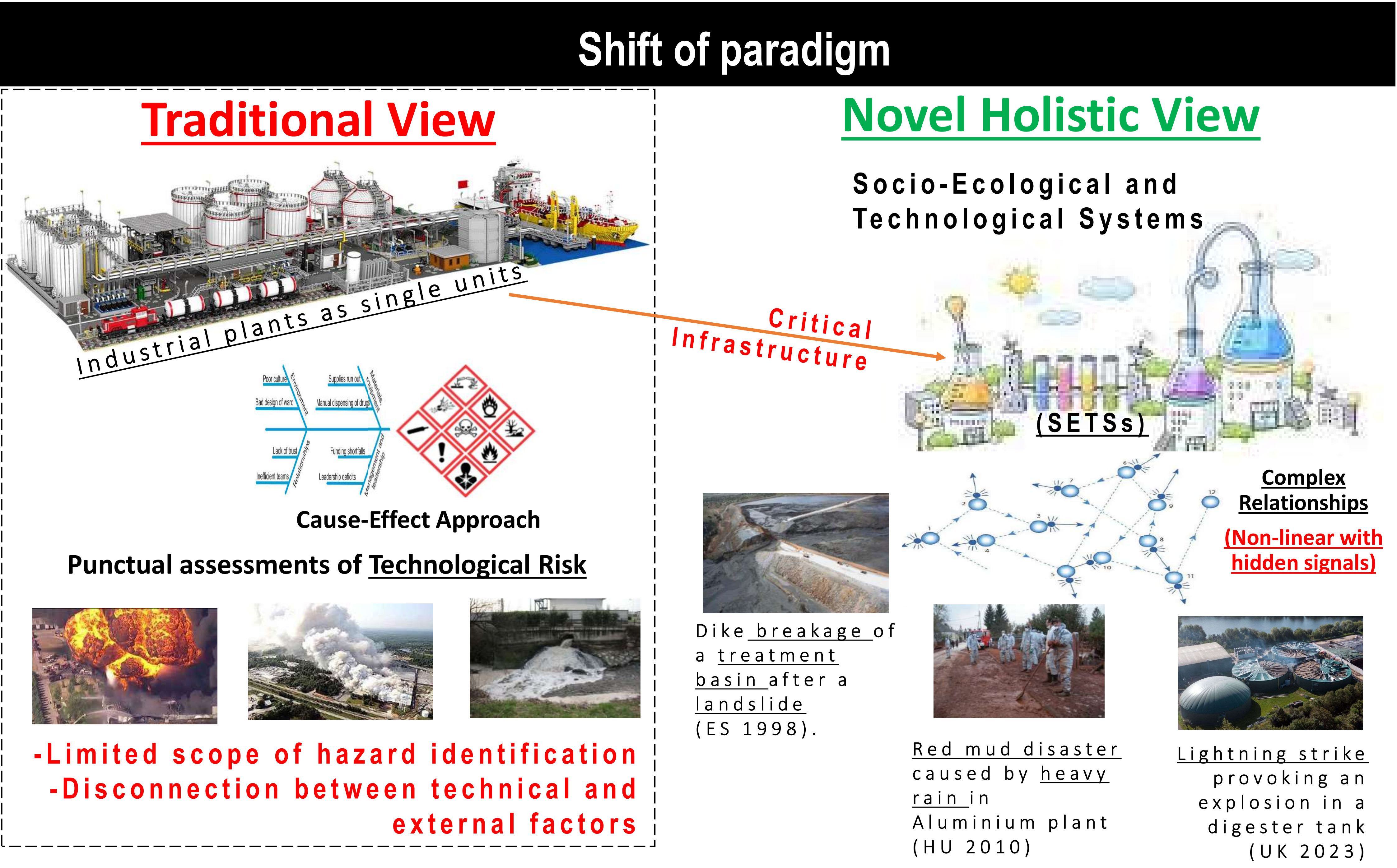


Directive (EU) 2022/2557
«on the **resilience** of critical entities»

Need Integration

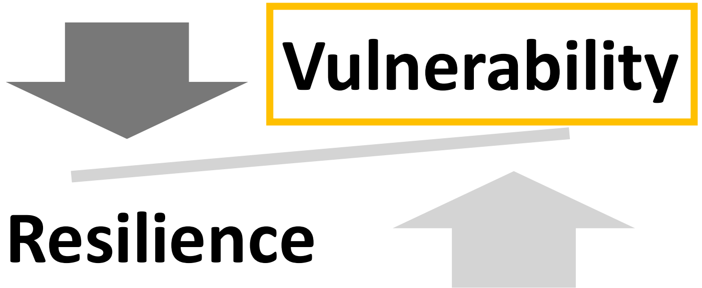
Directive 2012/18/EU
«controlling major accident hazards involving hazardous substances»

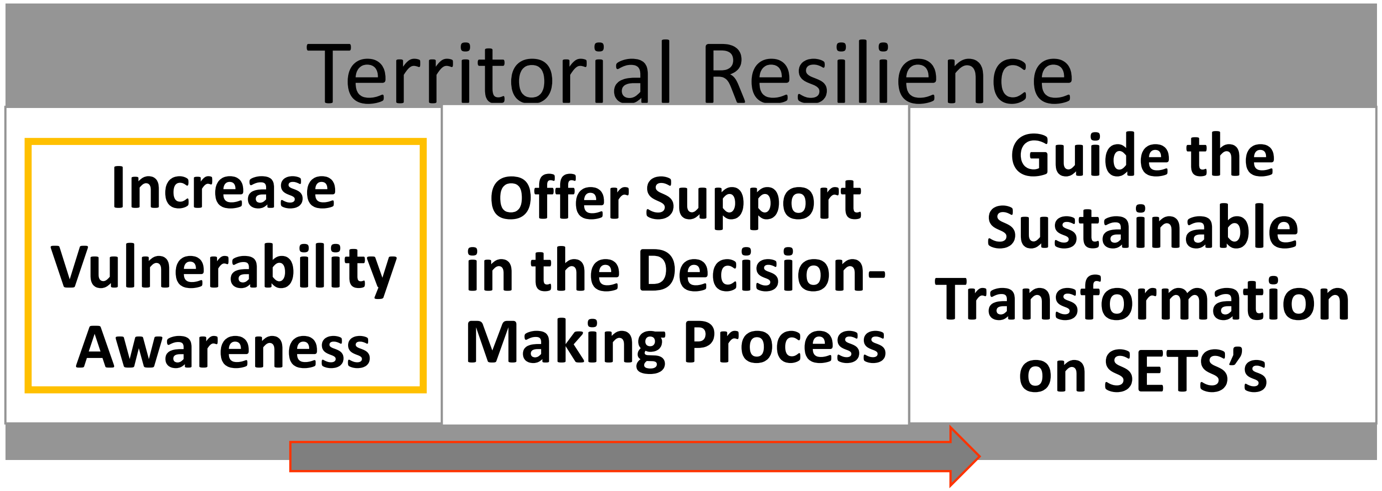
Industrial sector among the Critical Infrastructure (CI) with higher potential losses

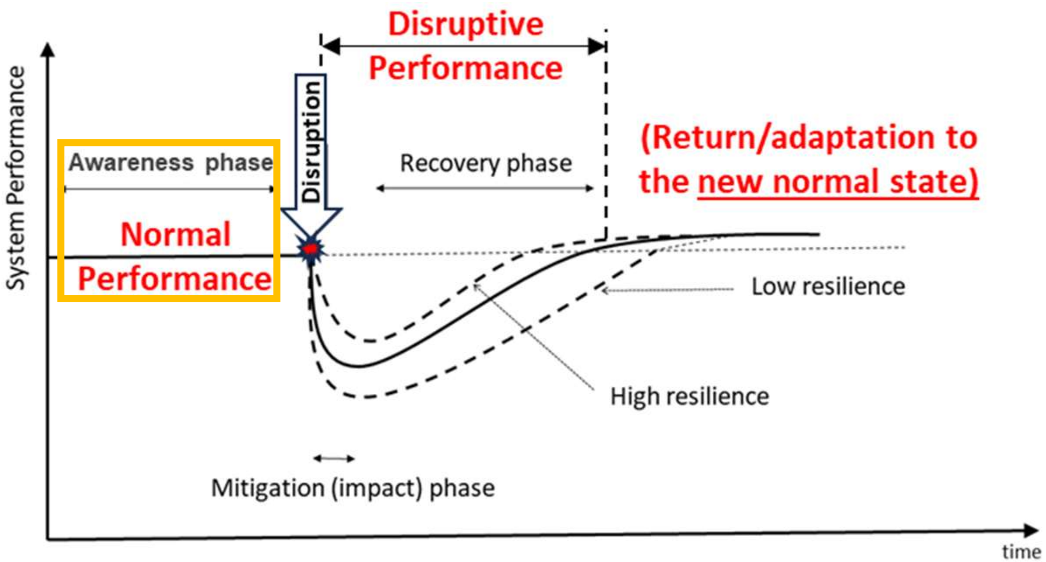

Shift of paradigm
Traditional View
Industrial plants as single units
Poor culture
Environment
Supplies run out
Bad design of ward
Manual dispensing of drugs
Lack of trust
Relationships
Funding shortfalls
Inefficient teams
Leadership deficits
Cause-Effect Approach
Punctual assessments of Technological Risk
-Limited scope of hazard identification
-Disconnection between technical and external factors
Critical Infrastructure
Novel Holistic View
Socio-Ecological and Technological Systems
(SETSs)
Complex Relationships
(Non-linear with hidden signals)
Dike breakage of a treatment basin after a landslide (ES 1998).
Red mud disaster caused by heavy rain in Aluminium plant (HU 2010)
Lightning strike provoking an explosion in a digester tank (UK 2023)

Different Resilience Approaches: Vulnerability awareness as common element

Territorial Resilience is a central topic in the debate on multi-hazards affecting SETSs.

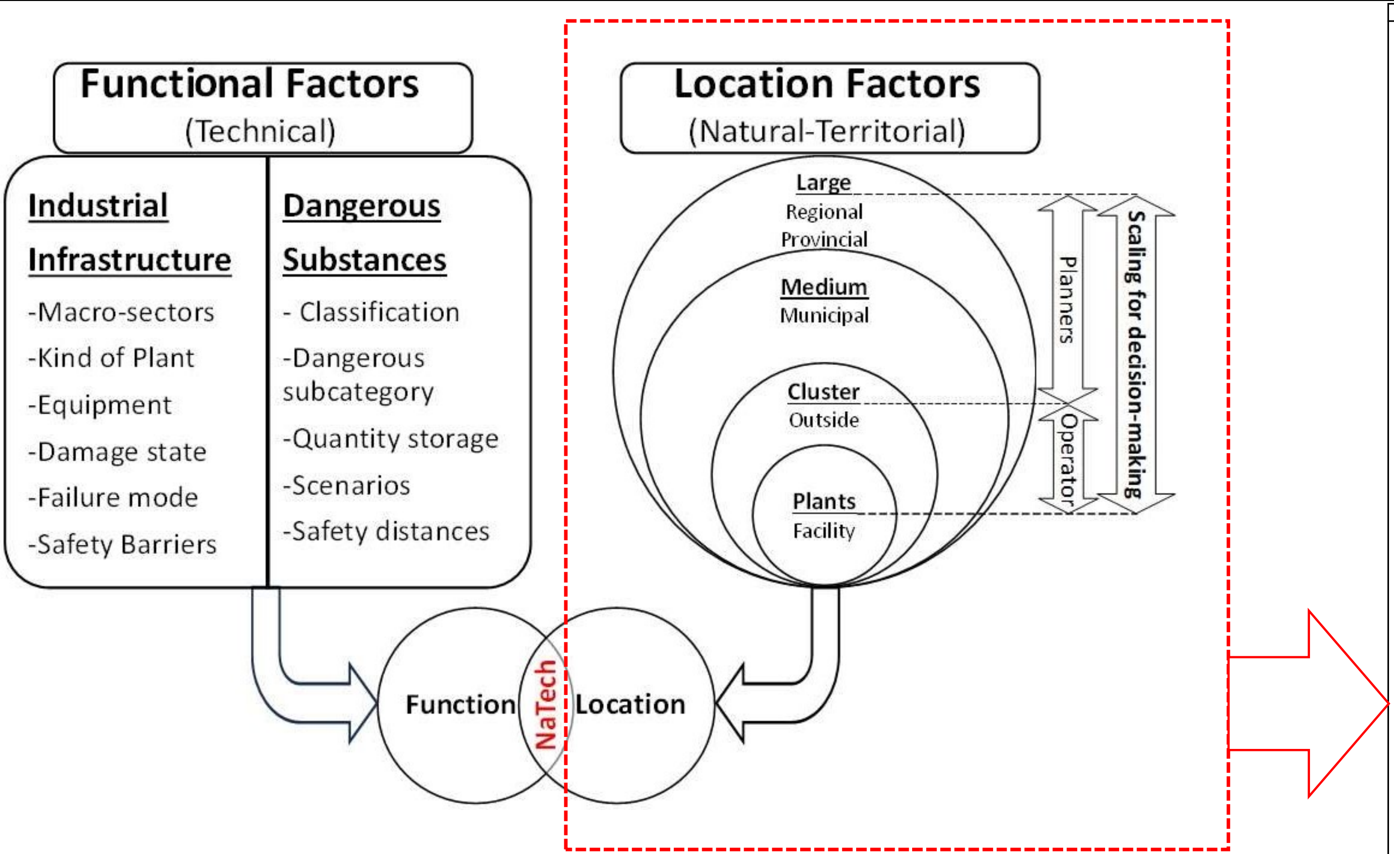


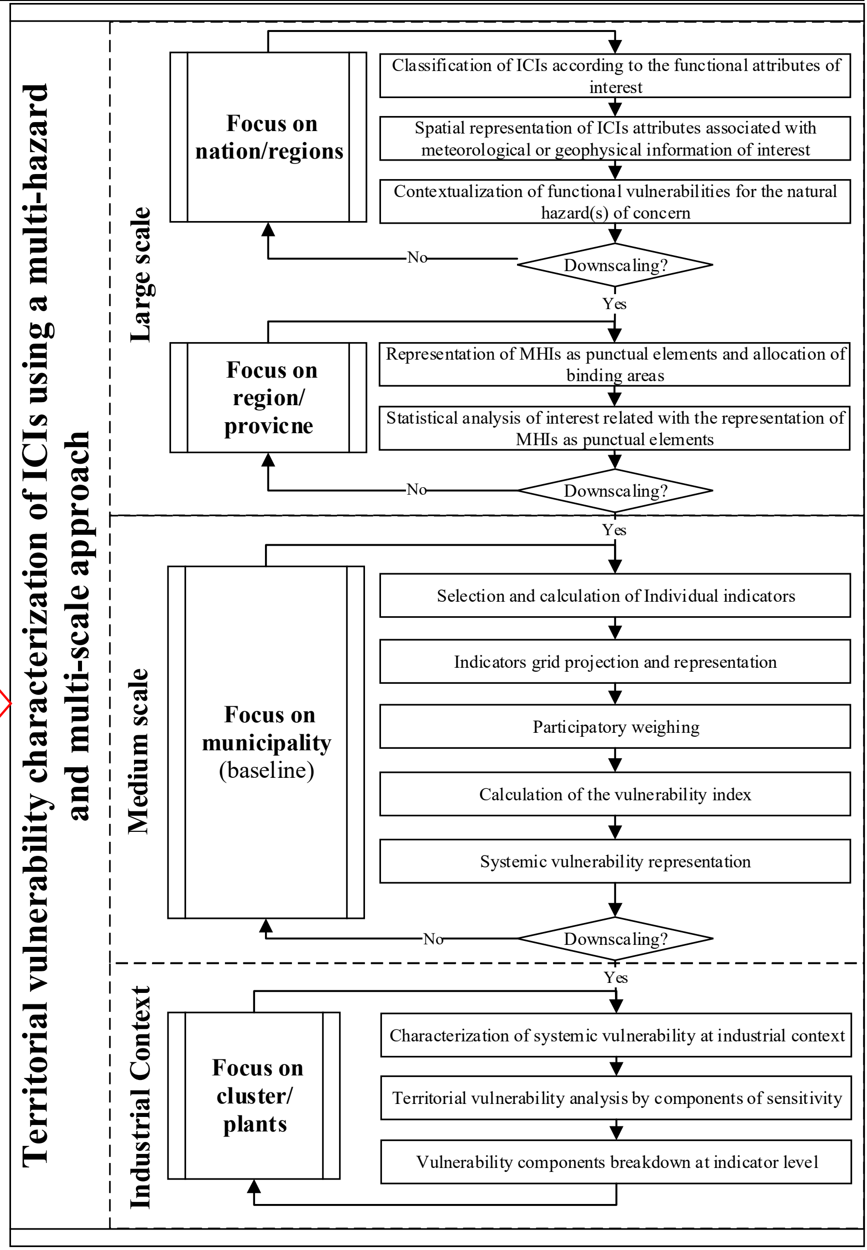




For Critical Infrastructure analysis resilience is approached into three phases according to the disruption profile.

Place-based procedure for characterizing the NaTech vulnerability





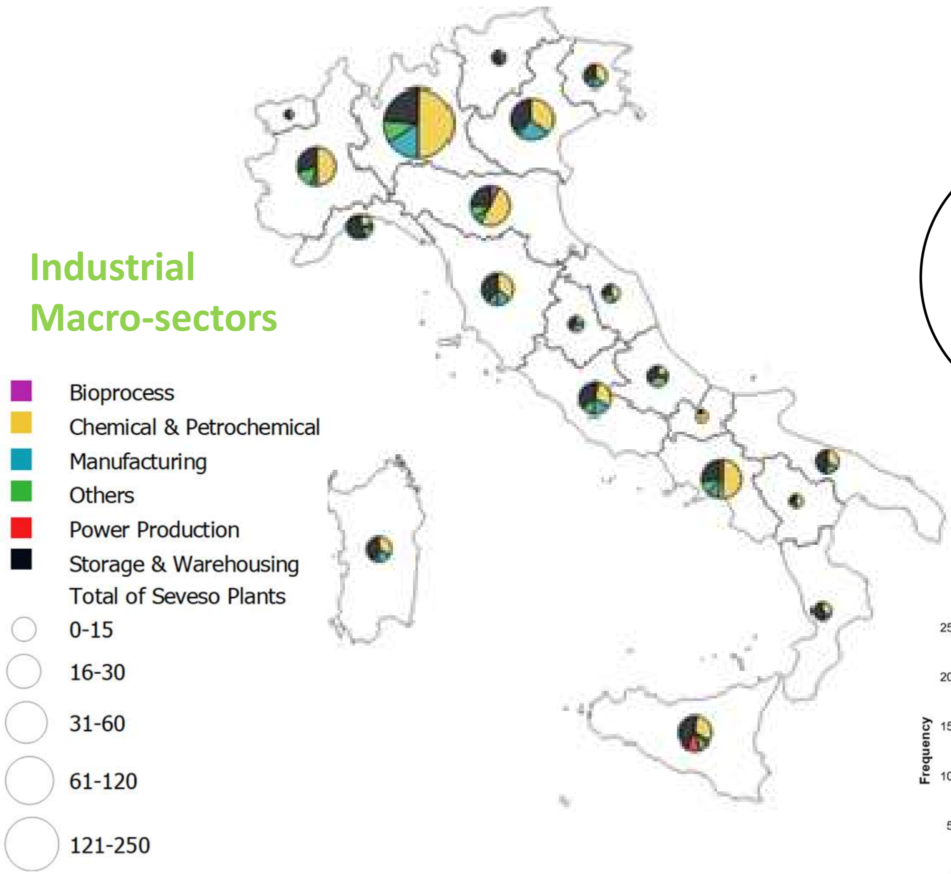
Function-Location Approach

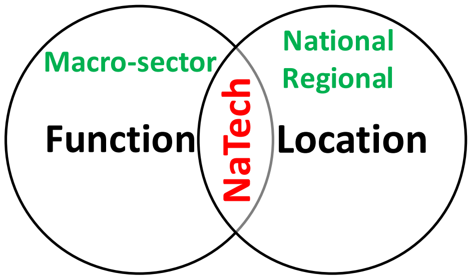
Multi-level framework to support the decision-making process in industrial multi-hazards contexts.

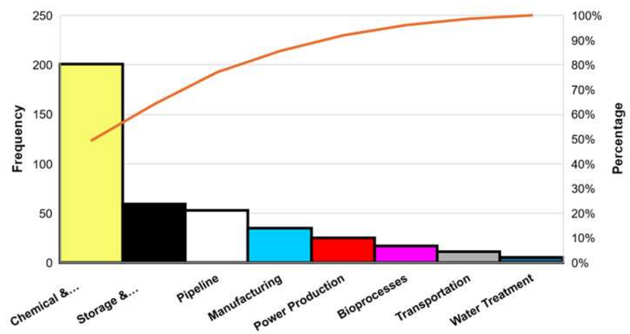
Focus on Nation/region (Large scale)

a) Pie-charts by region for industrial macro-sectors.

Higher industrialization at north







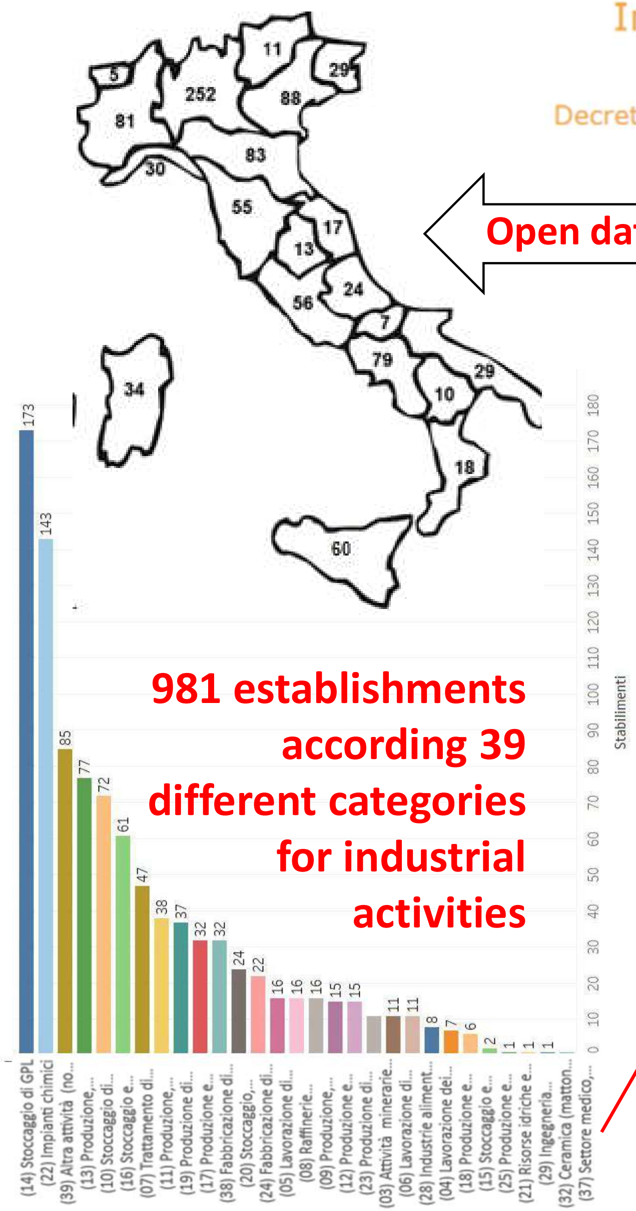
b) Density of lightning to the ground (lightning/year·km^2).

Higher lightning density at north.

Focus on Nation/region (Large scale)

Inventario degli stabilimenti a rischio di incidenti rilevanti connessi con sostanze pericolose

Decreto legislativo 26 giugno 2015, n. 105 – Recepimento Direttiva 2012/18/UE "Seveso Ter"



Open data

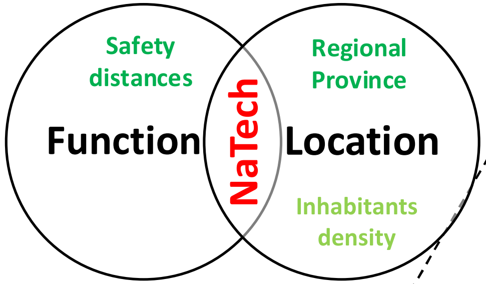
981 establishments according 39 different categories for industrial activities

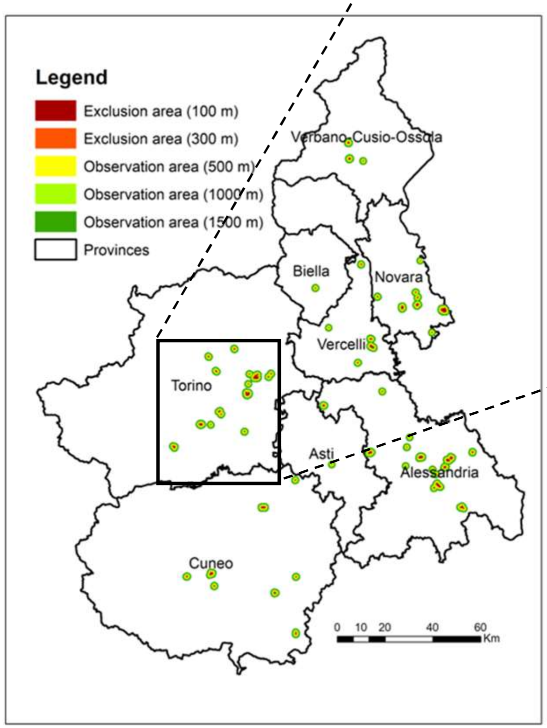
Re-Categorization

8 categories of Macro-sector within the Process Industry

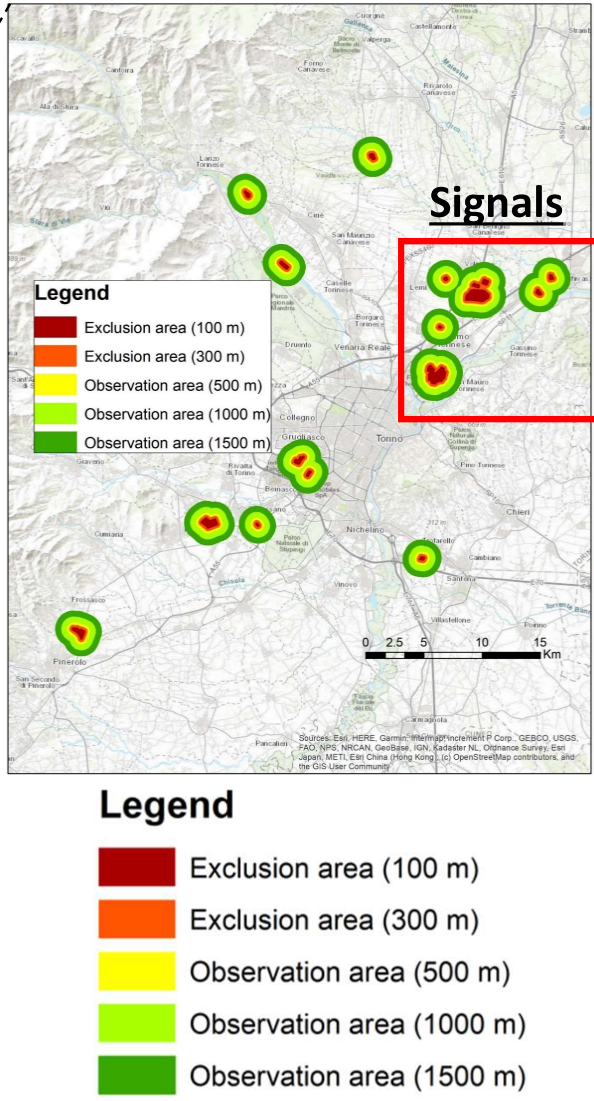
Macro-sector	Description (Casson Moreno et al., 2018)
Chemical & Petrochemical	Chemical activities, including pesticides production, pharmaceutical industry, production of basic chemicals. Petrochemical activities, including refineries.
Storage & Warehousing	Sites where chemicals are stored in appointed equipment (i.e. storage tanks) and storage buildings (warehouses/depots).
Power production	Power production plants using hydrocarbons (thermal power stations). Nuclear power plants were not included in the present analysis.
Bioprocesses	Treatment of organic waste and waste fermentation juices; food industry.
Water treatment	Treatment of water for industrial and domestic purposes (excluding bioprocesses-related waters and slurries).
Transportation	Transportation of hazardous materials via road, rail and water.
Pipeline	Oil and gas transportation via pipelines.
Manufacturing	Metal working, textile industry, activities related to automotive sector where hazardous substances are used.

Focus on Region/Province (Large scale)



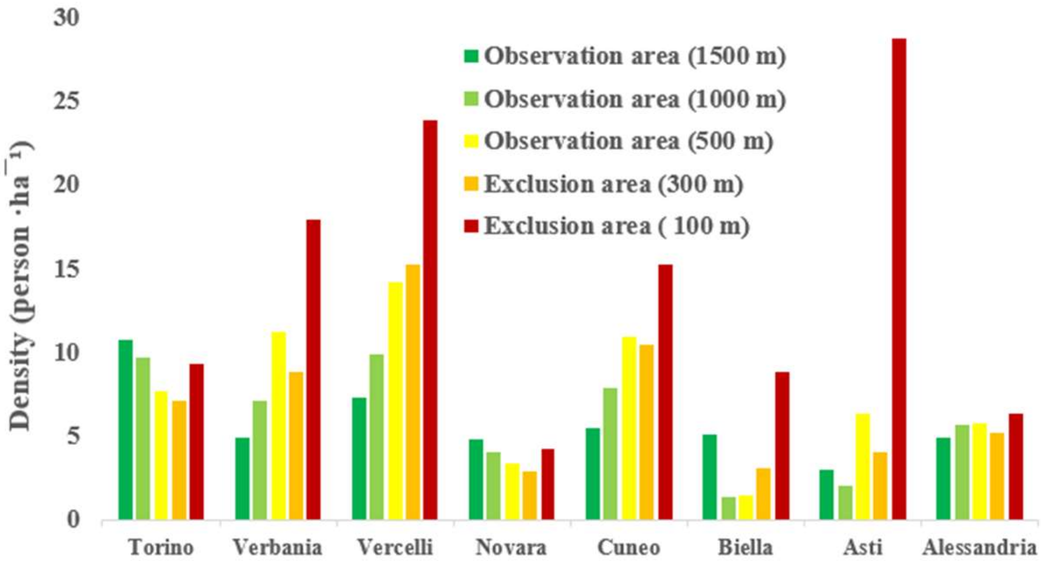


Punctual representation of ICI in Piedmont.



Allocation of buffer zones (Exclusion and observation areas).

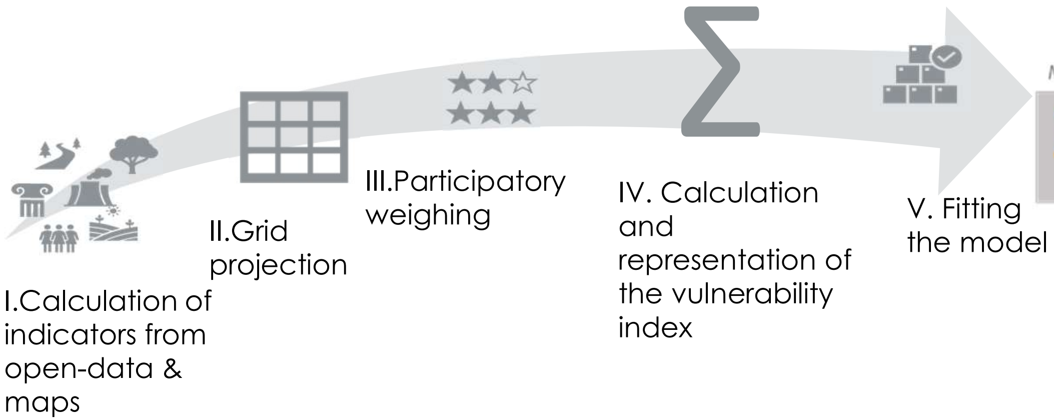
High concentration of establishments (Potential Area RIR—*Rischio Incidente Rilevante*—) with implications for domino effect.



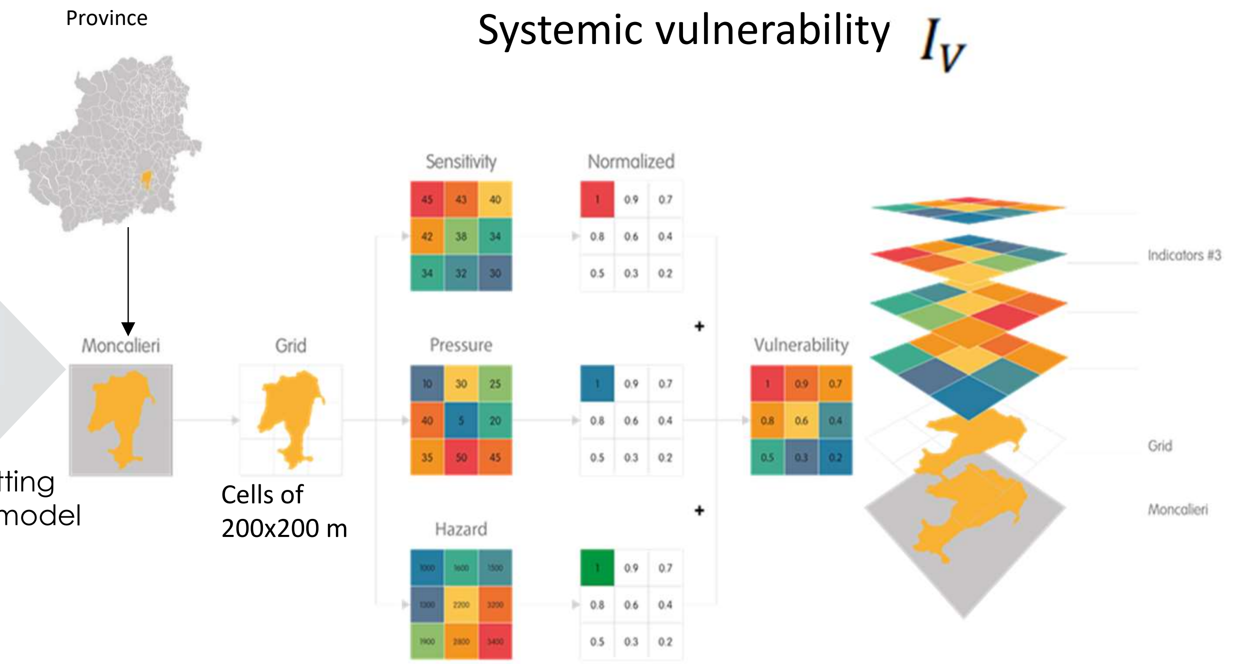
Statistical analysis in the potential damaged areas at different scales (i.e., Vulnerable population for province).

Focus on Municipalities (Medium scale)

Tool to measure the local vulnerability using a <u>multi-risk approach</u>, which integrated multiple indicators superposed in the same location clustered into three factors defined as, Sensitivities, Pressures, and Hazards.



Systemic vulnerability I_V



Sensitivities

Environment and Landscape (A)

A1: Landscape sensibility	
A2: Ecological quality	
A3: Energy consumption intensity	

Building, Heritage, Infrastructures (B)

B1: Cultural heritage consistency	
B2: Building constructions characteristics	
B3: RES energy self-sufficiency	
B4: Communication infrastructure density	
B5: Road infrastructure density	

Economy and Population (C)

C1: Population density	
C2: Elderly population incidence	
C3: Immigrant population incidence	
C4: Manufacturing activities density	

Pressures / Hazards

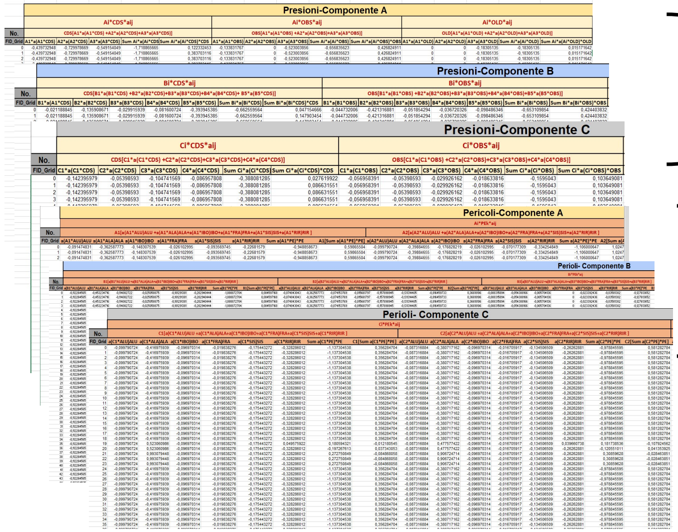
Pressures

CDS: Soil consumption	
OBS: Building obsolescence	
OLD: Ageing population	

Hazards

ALU: Flash floods	
ALA: Floods	
IBO: Wildfires	
FRA: Landslides	
SIS: Earthquakes	
RIR: Major industrial risk	

Focus on Municipalities (Medium scale): How the multi-risk tool works?



IPr= $IPrA + IPrB + IPrC$

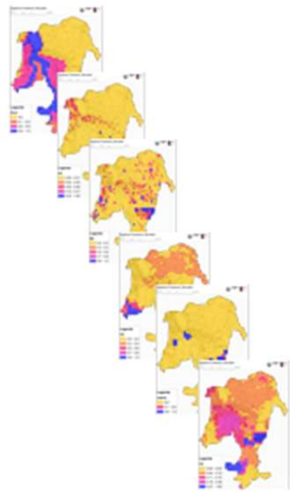
+

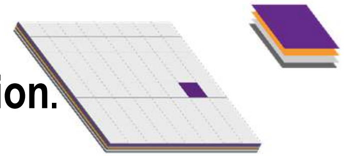
IPe= $IPeA + IPeB + IPeC$

=

$\boxed{Iv = IvA + IvB + IvC}$

I.- Calculation of Indicators





II.-Grid Projection Representation.

Mathematical Framework.

$$I_V = \alpha \cdot I_{PR} + (1-\alpha) \cdot I_{HZ}$$

I_{HZ} =Index of Hazards

I_{PR} = Index of Pressures

$\boldsymbol{\alpha}$ = coefficient of "interest"; ($\boldsymbol{\alpha} \in [0,1]$).

$$I_{HZ} = \sum_{w=1}^{W} \frac{\beta_w}{m_w p} \cdot \sum_{i=1}^{m_w} \sum_{k=1}^{p} \cancel{CC}(t)_k \cdot S_i \cdot b_{ik} \cdot HZ_k$$

where:

p= number of hazards.

m_A = number of sensitivities in component A.

$CC(t)_k$= a factor that expresses the impact of climate change

$CC(t)_k$=1) related to hazard k.

S_i= indicator of sensitivity i in the specific cell.

HZ_k = indicator of hazard k in the specific cell.

$$= \sum_{w=1}^{W} \frac{\beta_w}{m_w n} \cdot \sum_{i=1}^{m_w} \sum_{j=1}^{n} \cancel{K_{ij}}(t) \cdot S_i \cdot b_{ij} \cdot PR_j$$

where:

n= number of pressures.

m_A = number of sensitivities in component A.

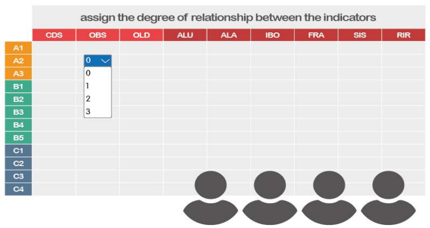
$K_{ij}(t)$= a factor that depends on the temporal nature of the pressure.

t_0=2020 one can fix $K_{ij}(t_0)$= 1).

S_i= indicator of sensitivity i in the specific cell.

PR_j = indicator of pressure j in the specific cell.

Expert from R3C group votation through a web application



III.-Participatory weighing.

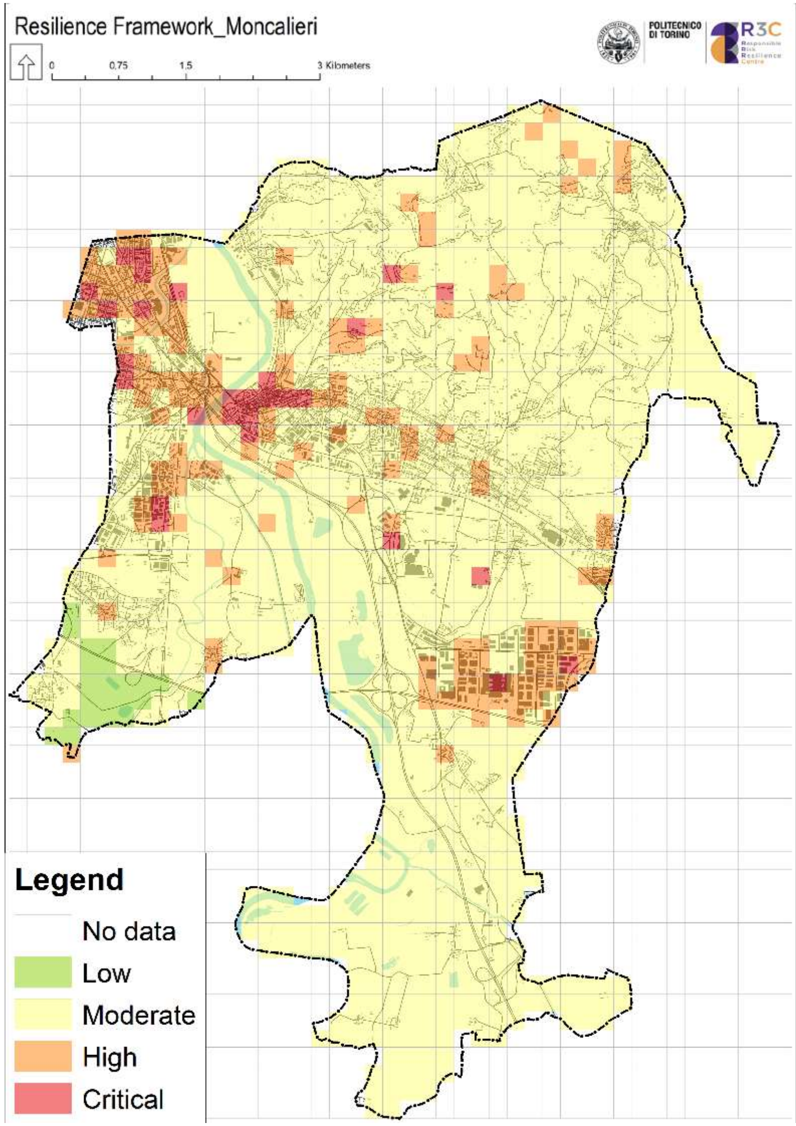
COMPONENTI DEL SISTEMA	Caracteristiche	Pressioni			Pericoli					
	Sensitività	CDS	OBS	OLD	ALU	ALA	IBO	FRA	SIS	RIR
A. Ambiente e Paesaggio	A.1 Sensibilità paesaggistica	0,70	0,21	0,00	0,67	0,61	0,79	0,76	0,48	0,58
	A.2 Qualità ecologica	0,79	0,00	0,00	0,73	0,67	0,94	0,76	0,36	0,85
	A3 Intensità del consumo energetico	0,64	0,61	0,21	0,27	0,24	0,18	0,18	0,09	0,21
B. Costruzioni, Infrastrutture, Beni Culturali e Paesaggio	B.1 Consistenza del patrimonio culturale	0,27	0,58	0,06	0,82	0,76	0,61	0,73	0,94	0,52
	B.2 Caratteristiche costruttive degli edifici (età)	0,30	0,94	0,00	0,55	0,61	0,39	0,45	0,82	0,33
	B.3 Autosuficenza energetica da FER	0,45	0,79	0,15	0,06	0,09	0,03	0,00	0,12	0,09
	B.4 Densità delle infrastrutture di comunicazione	0,61	0,27	0,18	0,61	0,55	0,64	0,64	0,70	0,64
	B.5 Densità delle infrastrutture viabilistiche	0,73	0,18	0,15	0,85	0,85	0,70	0,73	0,88	0,79
C. Economia, Popolazione	C.1 Densità di popolazione	0,45	0,18	0,61	0,73	0,70	0,52	0,58	0,91	0,83
	C.2 Componente anziana	0,09	0,09	0,91	0,64	0,64	0,52	0,48	0,70	0,67
	C.3 Componente immigrata	0,21	0,06	0,30	0,27	0,27	0,21	0,21	0,27	0,24
	C.4 Densità di attività produttive	0,42	0,09	0,12	0,73	0,67	0,58	0,55	0,70	0,82

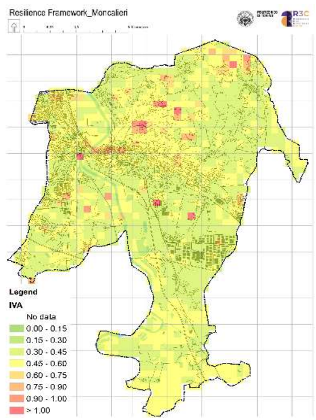
Multi-risk tool for vulnerability representation of sensible territorial elements.

IV. Principal output of the model for multi-level decision-making.

I_V Index of Systemic vulnerability

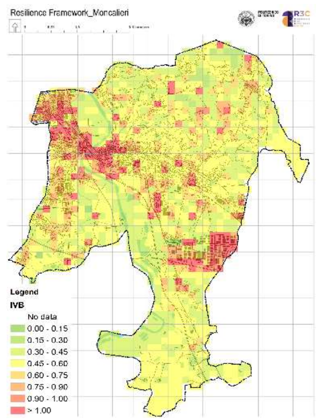
Vulnerability A+B+C





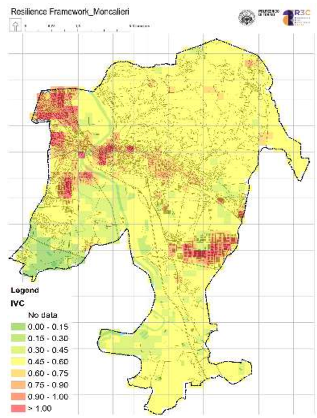
Vulnerability A

Environment and Landscape.



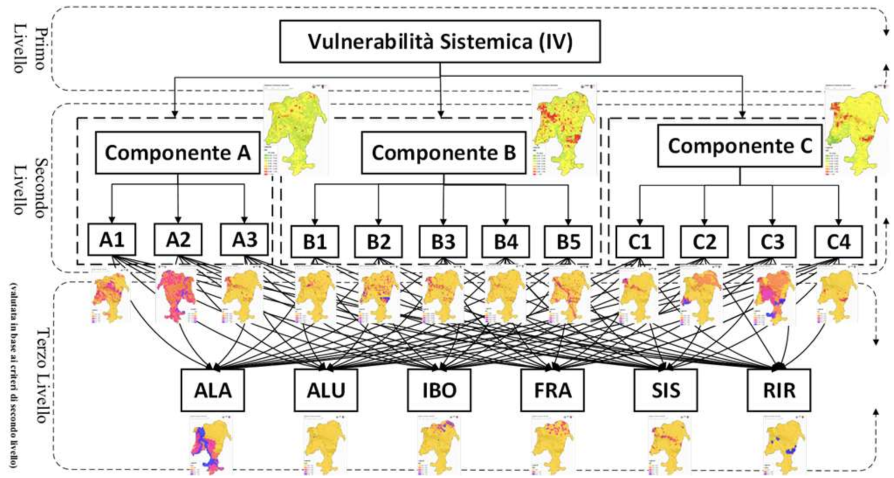
Vulnerability B

Buildings, heritage, Infrastructures.



Vulnerability C

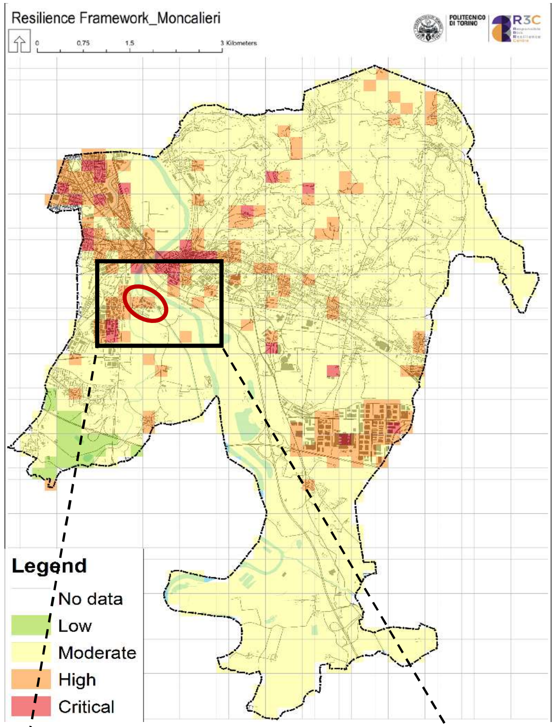
Economy and Population.



Network Vulnerability Structure (case of hazards).

Focus on Cluster/Plants (Industrial scale) : Proof of concept : Focus on ICI-territory

Systemic Multi-hazard Vulnerability



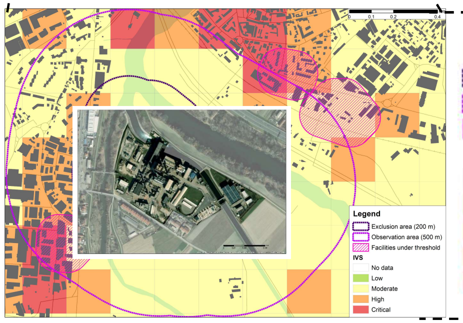
Power Production
Thermoelectric

NaTech

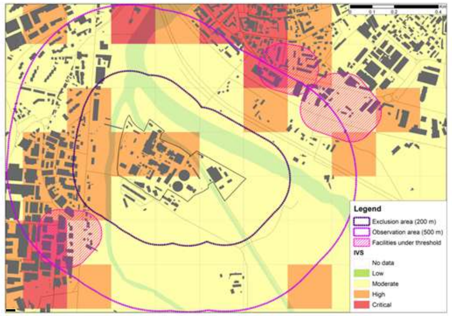
Industrial Context
Inside
and outside
the plant

Industrial Context
(280 ha, 70 cells)

- 26% with high vulnerability (orange), and 9% with critical vulnerability (red).
- 35 % inside the exclusion area with high vulnerability.



Legend
Exclusion area (200 m)
Observation area (500 m)
Facilities under threshold
IVS
No data
Low
Moderate
High
Critical



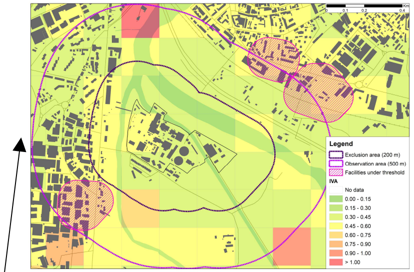
Production of energy from the combustion of hydrocarbons.

Vulnerability [0:1] 0 No vulnerability
1 Critical Vulnerability

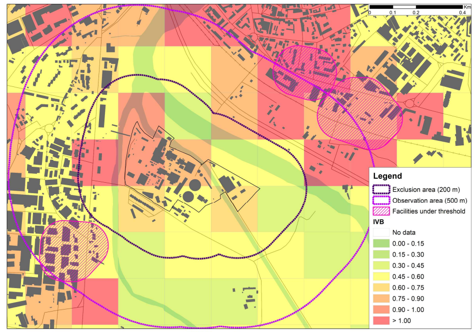
Downscaling-breakdown

First level-Components (A,B, C)

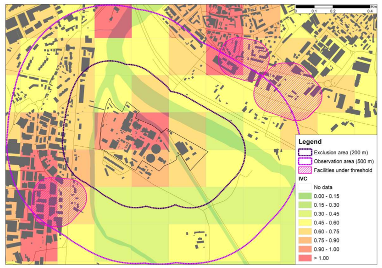
Second level-Hazards (some examples)



A: Environment and Landscape



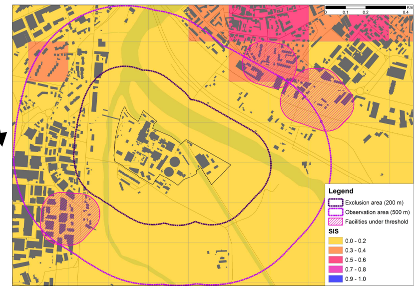
B: Buildings, heritage, Infrastructures



C: Economy and Population

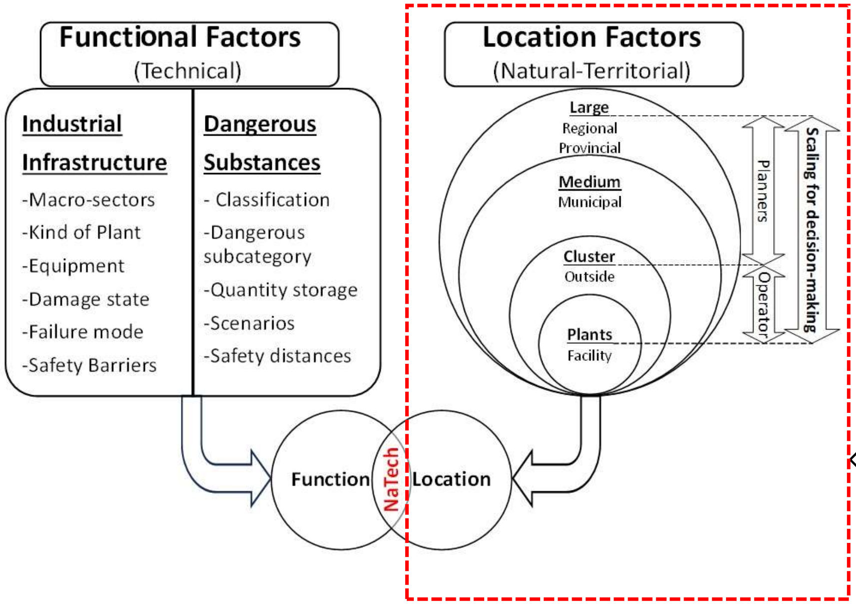
Floods vulnerability (high)

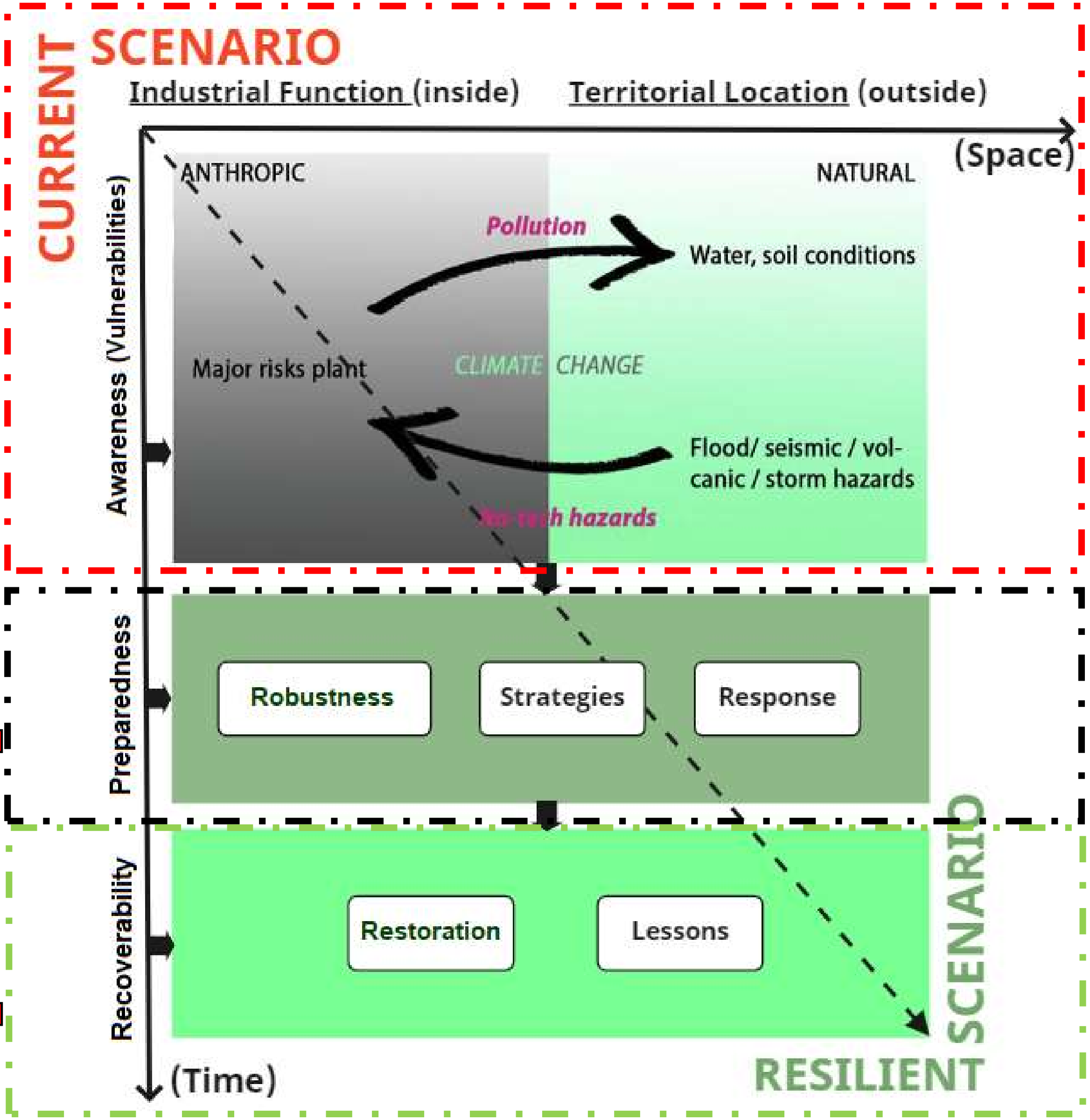
Neighboring facilities (medium)



Seismic-low vulnerability (low)

Implications





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The 33rd European Safety and Reliability Conference (ESREL 2023)
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Vulnerability Scenario Characterization in an Industrial Context using a Natech Indicator and a Territorial Multi-Risk Approach

David Javier Castro Rodriguez[1,a], Micaela Demichela[1,b], Simone Beltramino[2,d], Mattia Scalas[2,e], Grazia Brunetta[2,f] and Antonello A. Barresi[1,c]

[1]Department of Applied Science and Technology (DISAT), Politecnico di Torino, Italy.
[a]david.castro@polito.it
[b]micaela.demichela@polito.it
[c]antonello.barresi@polito.it
[2]Interuniversity Department of Regional and Urban Studies and Planning (DIST) Politecnico di Torino, Italy.
[d]simone.beltramino@polito.it
[e]mattia.scalas@polito.it
[f]mattia.scalas@polito.it


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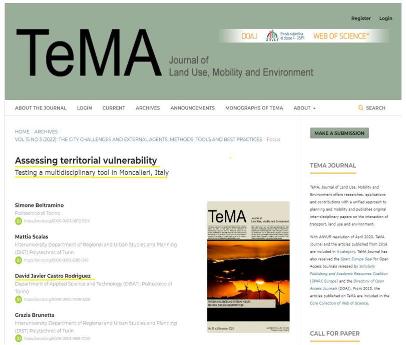
Territorial Representation of a Vulnerability Associated with the Seveso Installations in a Nord Italian Case Study

David Javier Castro Rodriguez[1,a], Simone Beltramino[2,d], Mattia Scalas[2,e], Eleonora Pilone[1,b], and Micaela Demichela[1,c]

[1]Department of Applied Science and Technology (DISAT), Polytechnic of Turin, Italy
[2]Interuniversity Department of Regional and Urban Studies and Planning (DIST) Polytechnic of Turin, Italy

ABSTRACT

The process industry is recognized as a source of hazards, both instantaneous and distributed over time and space. The industrial plants are no longer recognized as single independent units; they are, on the contrary, completing parts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Assessing territorial vulnerability
Testing a multidisciplinary tool in Moncalieri, Italy

Simone Beltramino
Politecnico di Torino
https://orcid.org/0000-0003-0872-951X

Mattia Scalas
Interuniversity Department of Regional and Urban Studies and Planning (DIST) Polytechnic of Turin
https://orcid.org/0000-0002-6912-1287

David Javier Castro Rodriguez
Department of Applied Science and Technology (DISAT), Politecnico di Torino
https://orcid.org/0000-0002-7609-3229

Grazia Brunetta
Interuniversity Department of Regional and Urban Studies and Planning (DIST) Polytechnic of Turin
https://orcid.org/0000-0003-1868-2700

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Ministero dell'Università e della Ricerca

Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

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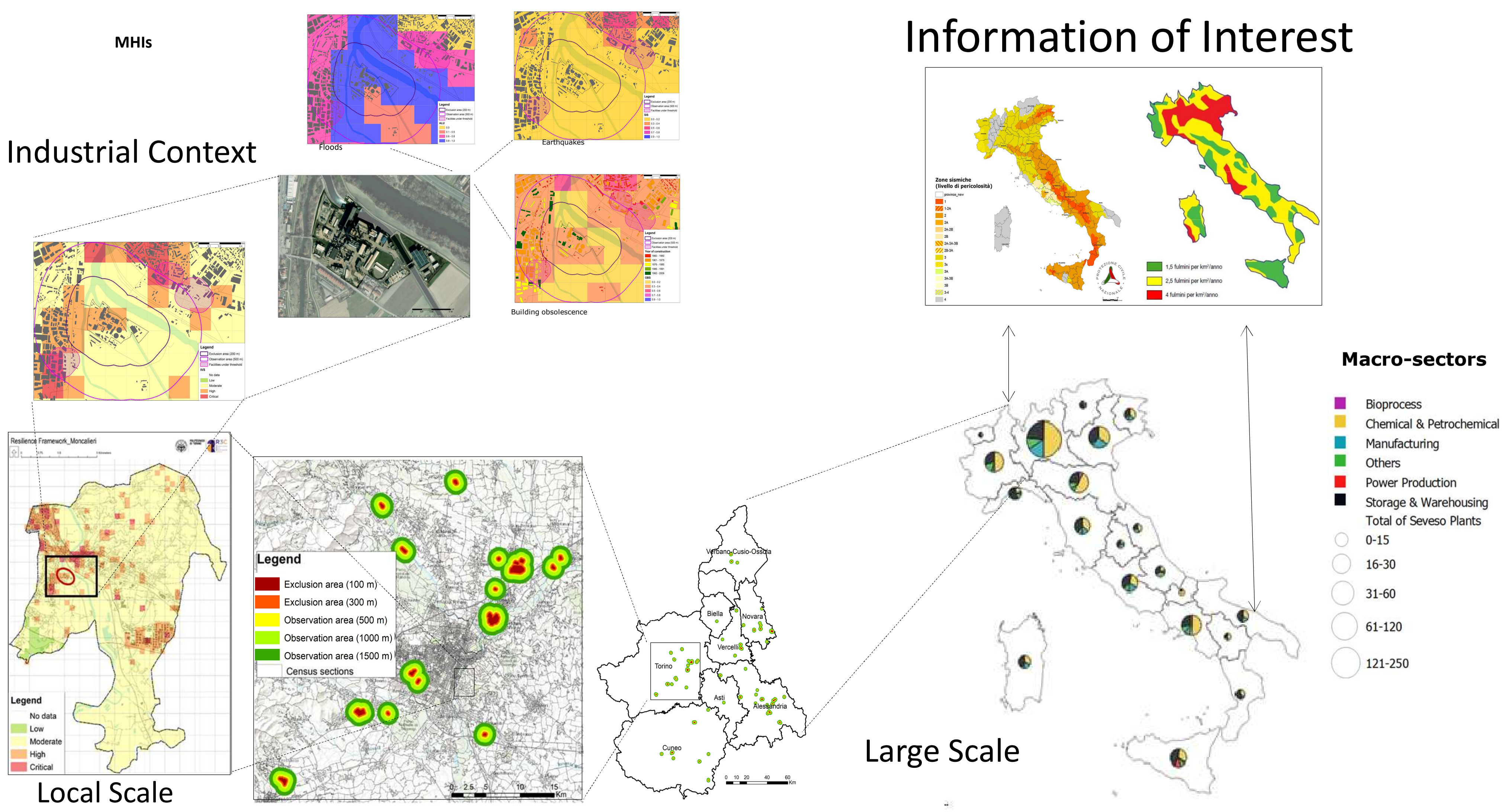
Return

R3C Responsible Risk Resilience Centre

Conclusions

- Data from the Italian inventory for Major Hazard Industries (MHIs) were grouped into industrial macro-sectors and illustrated by regions on national scale pie charts. These distributions were then correlated with meteorological or geophysical data of interest, from open access data, using the Function-Location approach.
- The development of a place-based procedure to establish safety distances, delineating exclusion, and observation areas around MHIs as buffer zones, assists in the identification of areas with high concentrations of establishments, where overlapping safety distances with neighbouring plants highlight potential implications for domino effects in case of NaTech events and enables the estimation of inhabitants in accident-prone areas.
- It also offers a swift and direct way to detect incompatibilities between existing or new establishments and minimum safety criteria for land use around Seveso sites, thus serving as an early detection system for territorial vulnerabilities in case of NaTech.
- The introduction of a GIS tool to assess municipal-scale territorial vulnerability employs a mathematical framework to calculate **systemic vulnerability**, initially neglected, integrating indicators within a hierarchical structure across three levels: systemic vulnerability, sensitivities, and multi-hazards. The resulting coloured maps effectively illustrate systemic vulnerability within a municipal context, providing **a comprehensive overview for decision-makers and stakeholders alike**.
- Summarizing, the application of advanced methods, integrating ICI attributes with their surrounding context across various scales, enriches the decision-making process in addressing NaTech events. This approach bridges the gap between technical and external factors, enhancing awareness against multiple hazards.

Schematization of vulnerability at different levels



Focus on Municipalities (Medium scale): How the multi-risk tool works?

Depending on the geometry of the input data - point, line, polygon - **the attribution** of the values obtained for each indicator **to the grid was carried out according to five criteria:** (i) point count (B1, ALA), (ii) sum of the point values (A3, B3, SIS), (iii) weighted sum of linear (B5) or areal elements (A1, A2, B2, B4, C4, CDS, OBS, IBO, FRA), (iv) average value of areas within the cell (C1, C2, C3, OLD) and (v) intersection between input polygons and each cell (ALU, RIR).

<u>The values assigned to the cells of the matrix were normalized to obtain a standard metric that allows the integration among the indicators and the following operations.</u>
Partial results were displayed in a 2550-row table – one for each 200x200 m cell that subdivides the territory - with 21 columns corresponding to each indicator