POLITECNICO DI MILANO
Reliability, Safety & Risk Analysis

Natural Technological (NaTech) Accidents,
Risk Assessment & Management

NaTech Accidents

Simone Pagliuca, Samule Mezzaro, Cyrille de Lurion

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What are NaTech Accidents?

Def.: NaTech accidents are Tech-related accidents influenced by Natural Events which can cause damages to infrastructures, people and the surrounding environment

Tsunami

Landslide

Great East Japan Earthquake and Tsunami (2011)

Injuries due to the H explosion,
Two workers suffered radiation burns
Some workers later died of leukemia

Substantial economic losses

Contamination of the
surrounding environment

Severe social and political consequences on the local community and the rest of the world

Fukushima NPP Accident

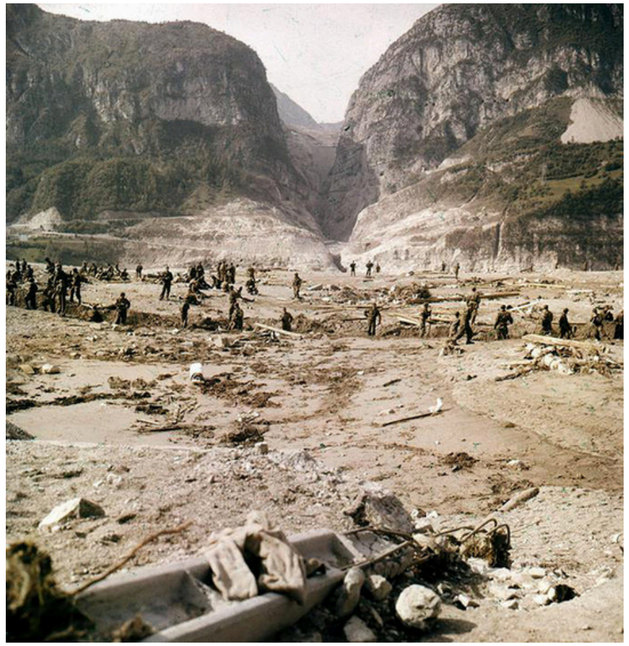
Landslide of Mount Toc (1967)

1917 people died

Massive damages to close inhabited areas and infrastructure.

Closest villages were completely swept away

~~Severe social and political consequences...~~



Vajont Disaster

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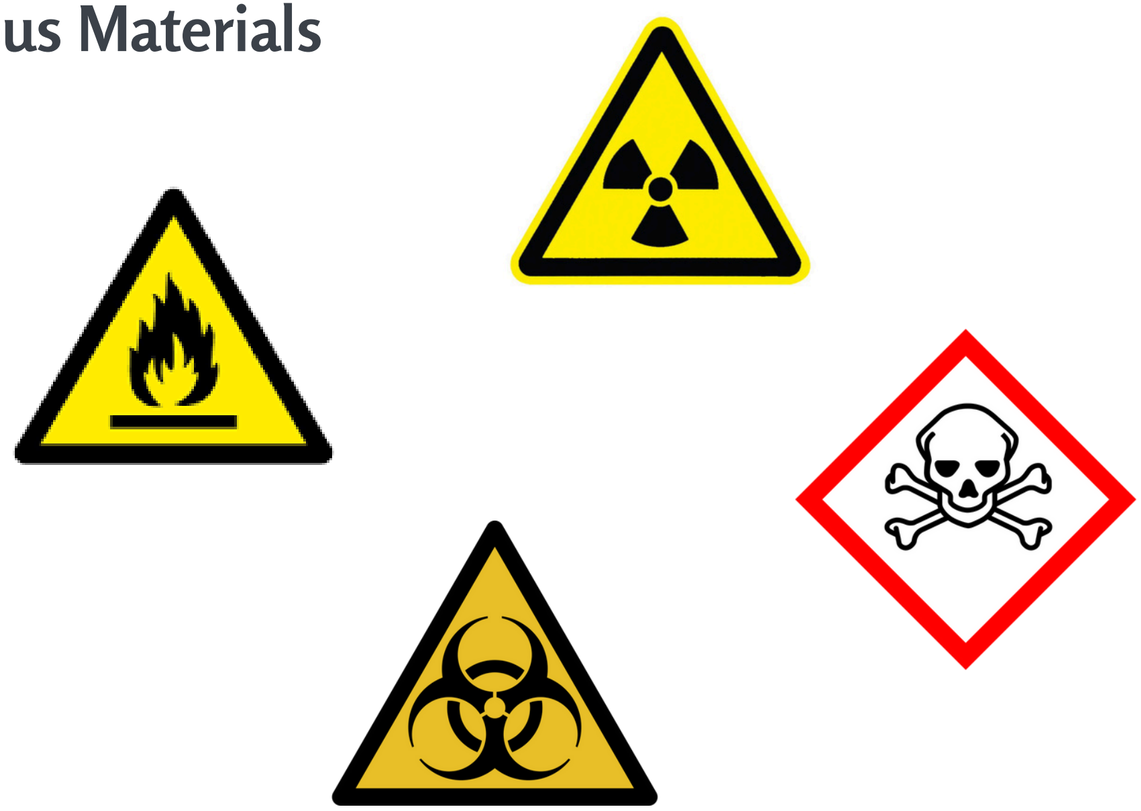
- What are NaTech Accidents?
- → When should NaTech Scenarios be considered?
- Current QRA
- Example of Risk Assessment
- Gaps & Issues

When should NaTech Scenarios be considered?

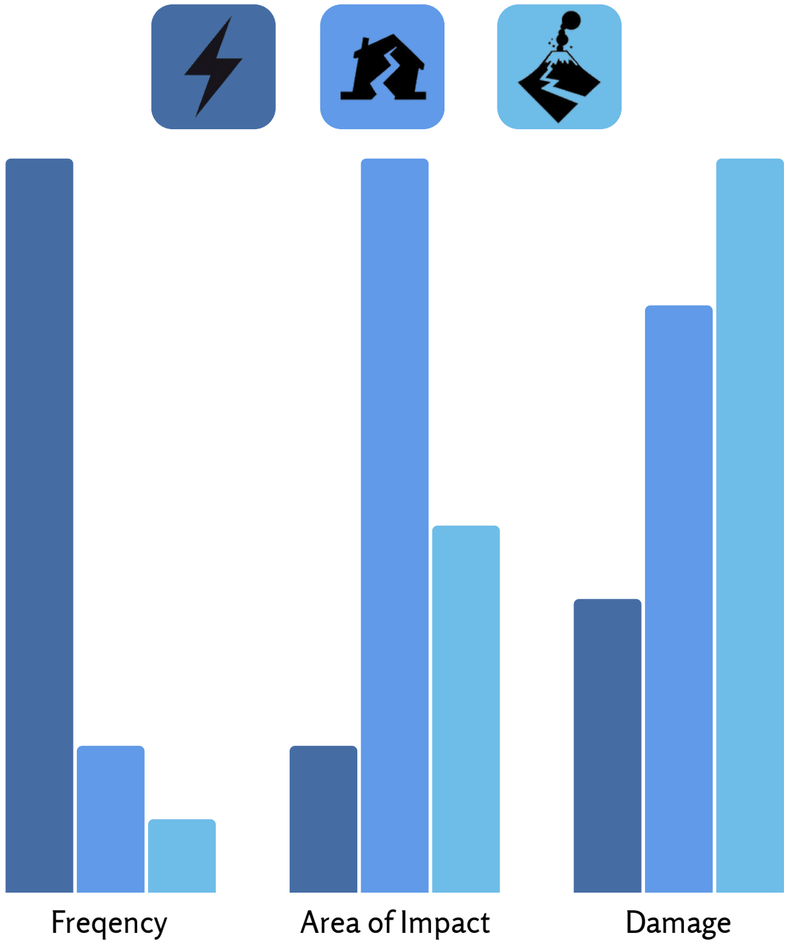
Any industrial plant that handles **Hazardous Materials**

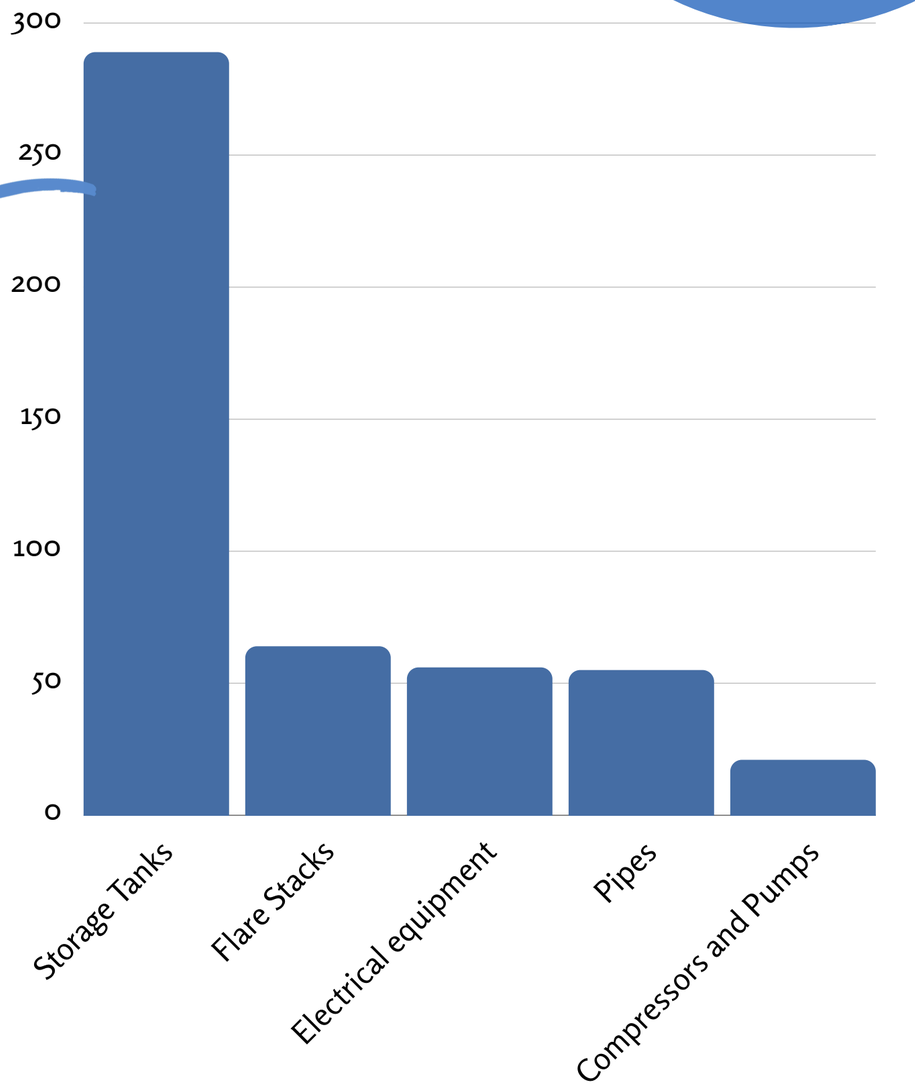


Why?

- **Emergency Planning**
- **Economic Consequences**
- **Social & Political Implications**

Causes and “Victims”…





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Current QRA

Basic Structure

1. Preliminary Data Gathering
2. Assessment of NaTech Scenario
3. *Assessment of Domino Escalation
4. Risk Evaluation

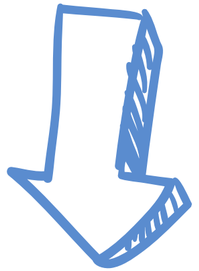
Current QRA

1: Preliminary Data Gathering

Choose the natural event and its magnitude.

1967	*Genova, IT*	*Fire from a tank spread to others,* *300 tons of oil lost*
1971	*Poland*	*Oil storage ignited and collapsed,* *Involved 3 other tanks,* *It caused 33 fatalities*
1989	*China*	*Crude oil tank with 40'000 tons ignited* Involved 5 similar tanks 16 fatalities and 70 injuries
...	...	...

Earthquakes: Peak ground acceleration
Floods: Water depth and velocity
Lightnings: Flash density



Data can be extracted from:

- Historical data,
- Natural hazard maps (if they exist)
- Empirical correlations

Current QRA

2: Primary NaTech Scenario

Lightning Impact

1. Pool Fire
2. Explosion
3. Jet Fire
4. Toxic Dispersion
5. No Consequence

Individuate possible system states
Define the failure or damage probabilities
Include only plausible combinations of events

Estimation of the failure probability:

- Fragility curves
- Vulnerability models
- Statistical models

Main difference between models

Current QRA

3: Domino Escalation

Not all methodologies include this step

Useful for storage facilities closely packed together

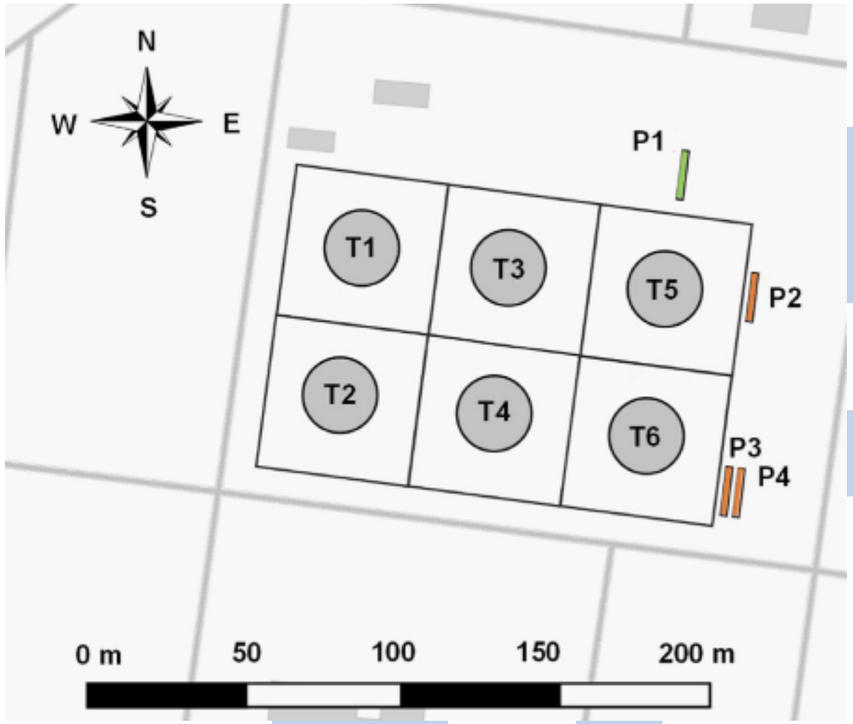
Escalation Vectors:

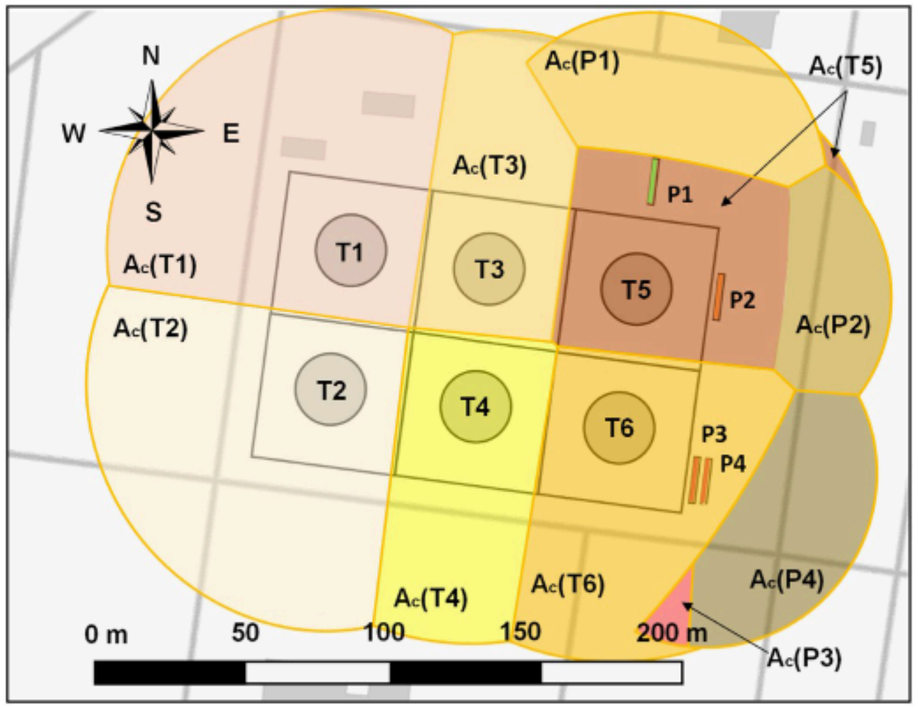
Radiation heat from fire
Fragment collisions from explosions
Release of toxic substances are neglected

Conditional escalation probabilities established, **for each**:

- Component
- Escalation Vector
- Primary Event
- Geometry

Several levels of escalations can be considered.





Current QRA

4: Risk Evaluation

Multiple sources of physical effects,
such as heat radiation and toxic concentration

Conventional models for consequence analysis **cannot be applied**

Map of death probability for the **overall escalation scenario**

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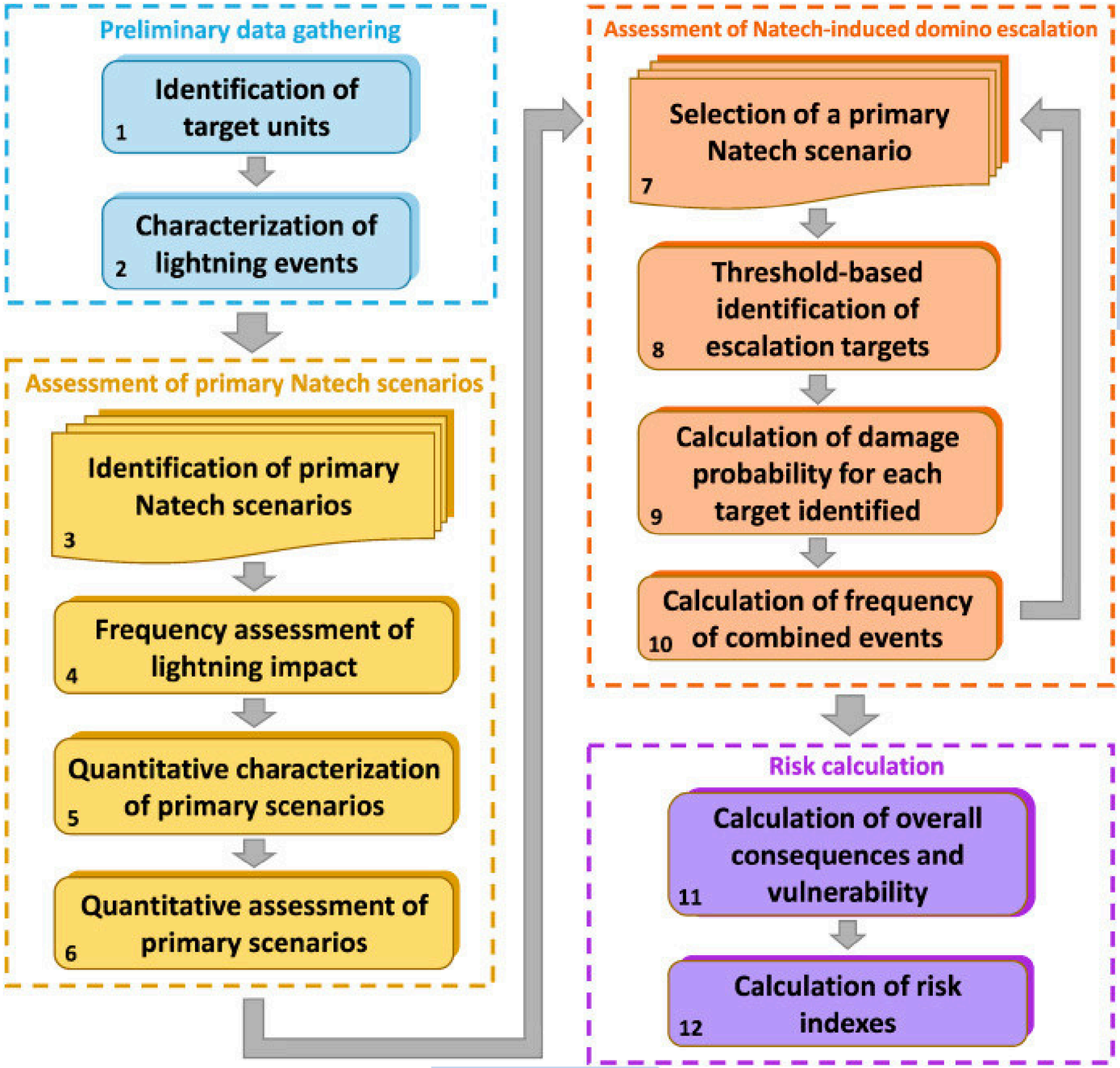
Example: Misuri et Al.

Methodology

Primary Scenarios: Single lightning. This event has low probability to cause damage to more than one unit.

Secondary Scenarios: nearby units are damaged as a consequence of the primary scenario.



Example: Misuri et Al.

Introduction

Focus on Domino effect of NaTech accidents triggered by lightning

Aim to extend previous QRA of NaTech scenarios induced by lightning to escalation scenarios caused by domino effects.

Lightnings are responsible for 95% of NaTech accidents in the Oil&Gas and Petrochemical sectors.

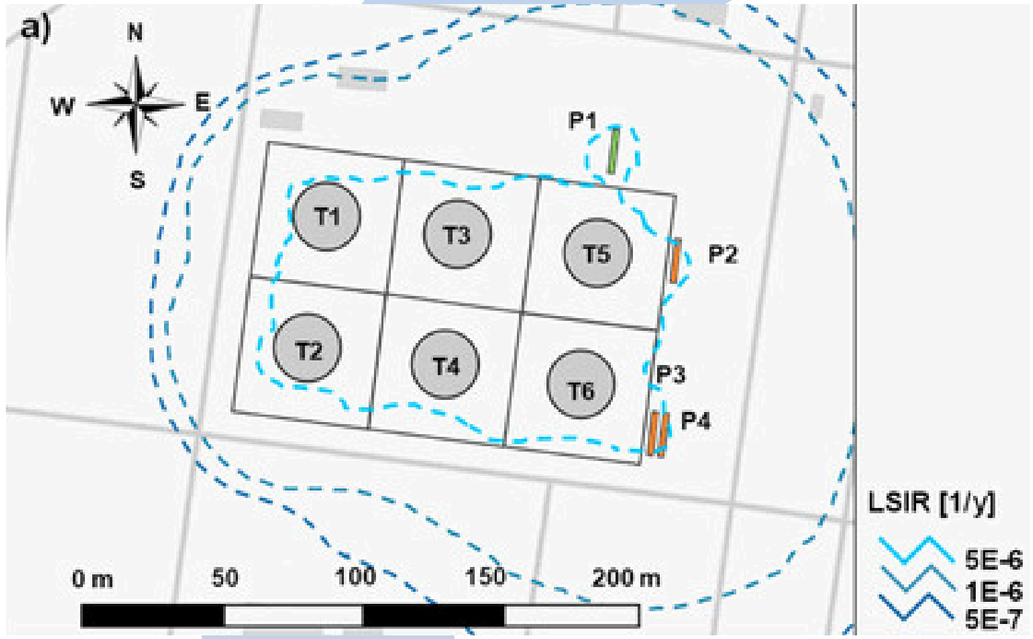
Example: Misuri et Al.

Results

6 atmospheric tanks storing gasoline,
3 pressurized horizontal vessels storing GPL
1 horizontal vessel storing ammonia

LSIR = Local-Specific Individual Risk

$$LISR = 10^{-6} \sim 10^{-7}$$

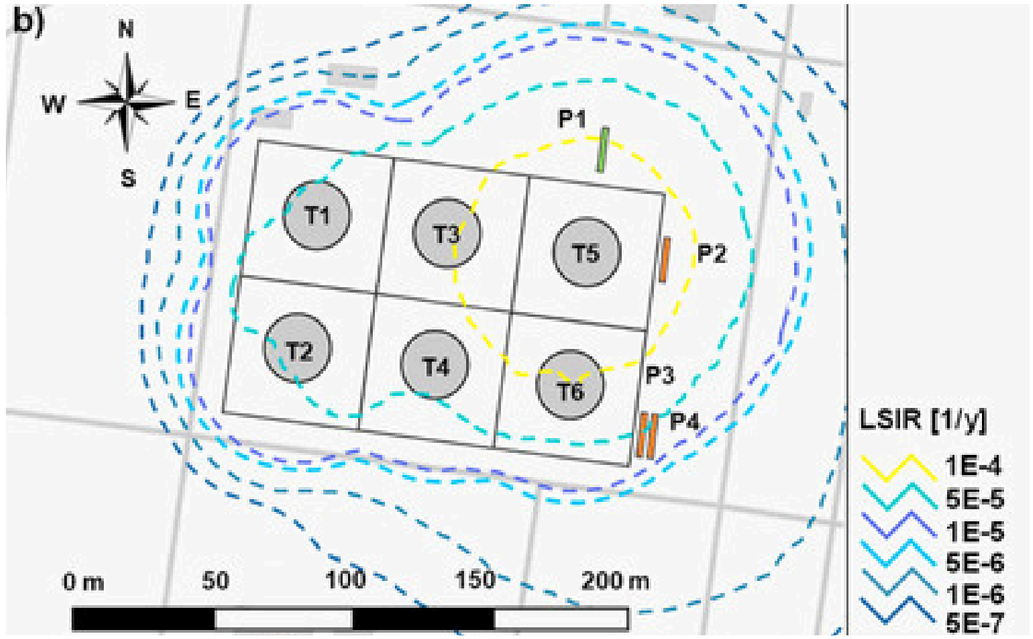


Conventional Evaluation

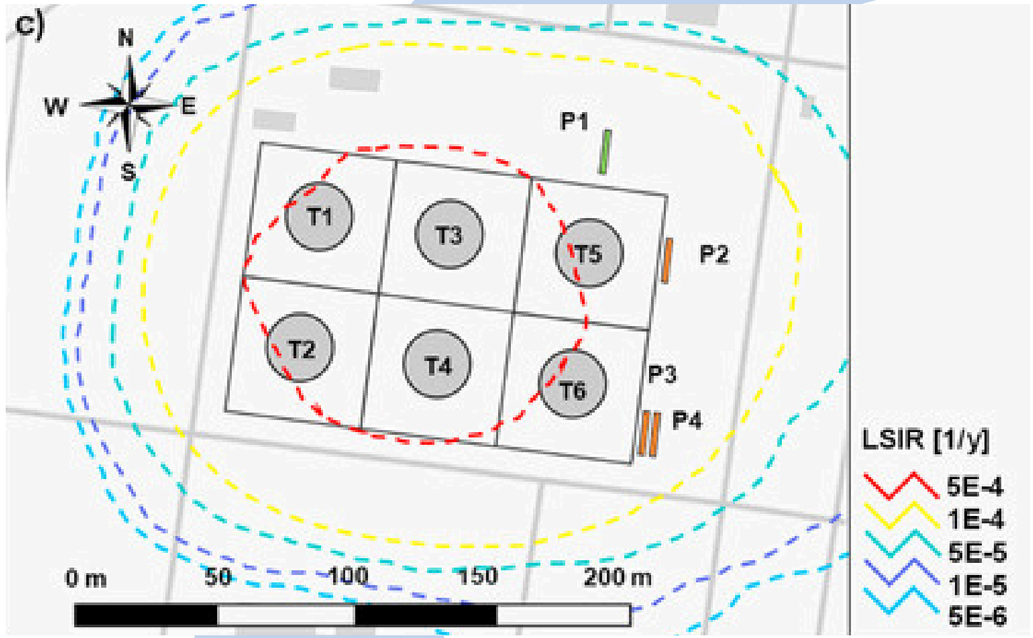
Example: Misuri et Al.

Results

Conventional + NaTech



Conventional + NaTech + Domino



$$LISR = \sim 10^{-4}$$

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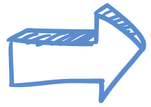
Gaps & Issues

Common issues

Rare occurrence rate
Not all disasters are well documented
Accidents not always recognized as “NaTech”



Scarcity of Available Data

Famous disasters with numerous casualties
but very low probability of occurrence like Tsunamis and earthquakes

are “more interesting” then

Frequently occurring but lower magnitude natural events:
lightning, rain, landslides, extreme temperatures

Human Bias

Gaps & Issues

Research gaps

Effects of the **warning time** before a disaster

Consequences of the event in respect to the **emergency response**

- Effect on workers and emergency responders
- Effect on Emergency infrastructure/resources

Post disaster planning:

BCP: Business Continuation Planning

R3: Recovery, Reconstruction, Renovation

Gaps & Issues

Research gaps

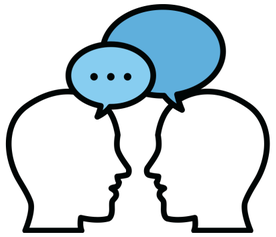
Lack of models covering “Side Effects” beyond immediate damage:

Risk Communication

Risk Perception

Health impact

For all, the workers, the surrounding population and the general public

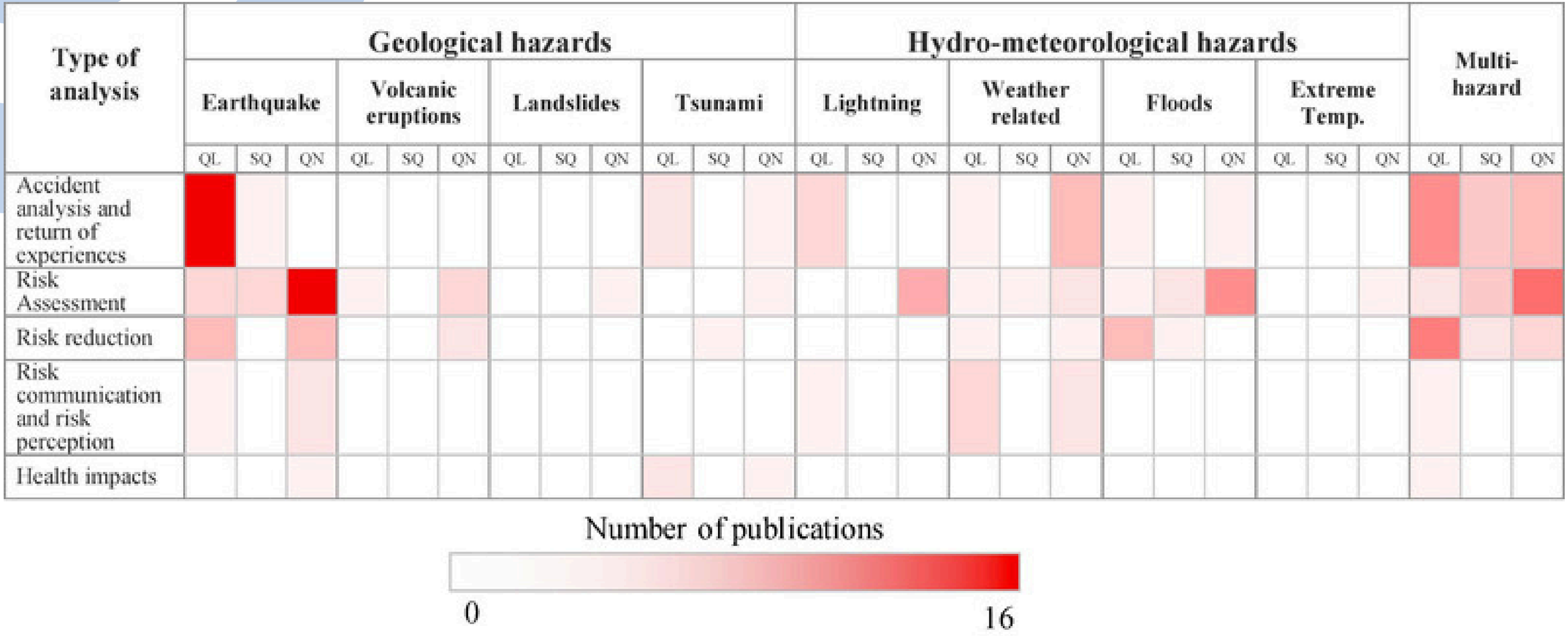


Outdated model approach

Most models use either quantitative or qualitative approaches instead of a, more promising, semi-quantitative approach

Gaps & Issues

Methodologies



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Thank you !

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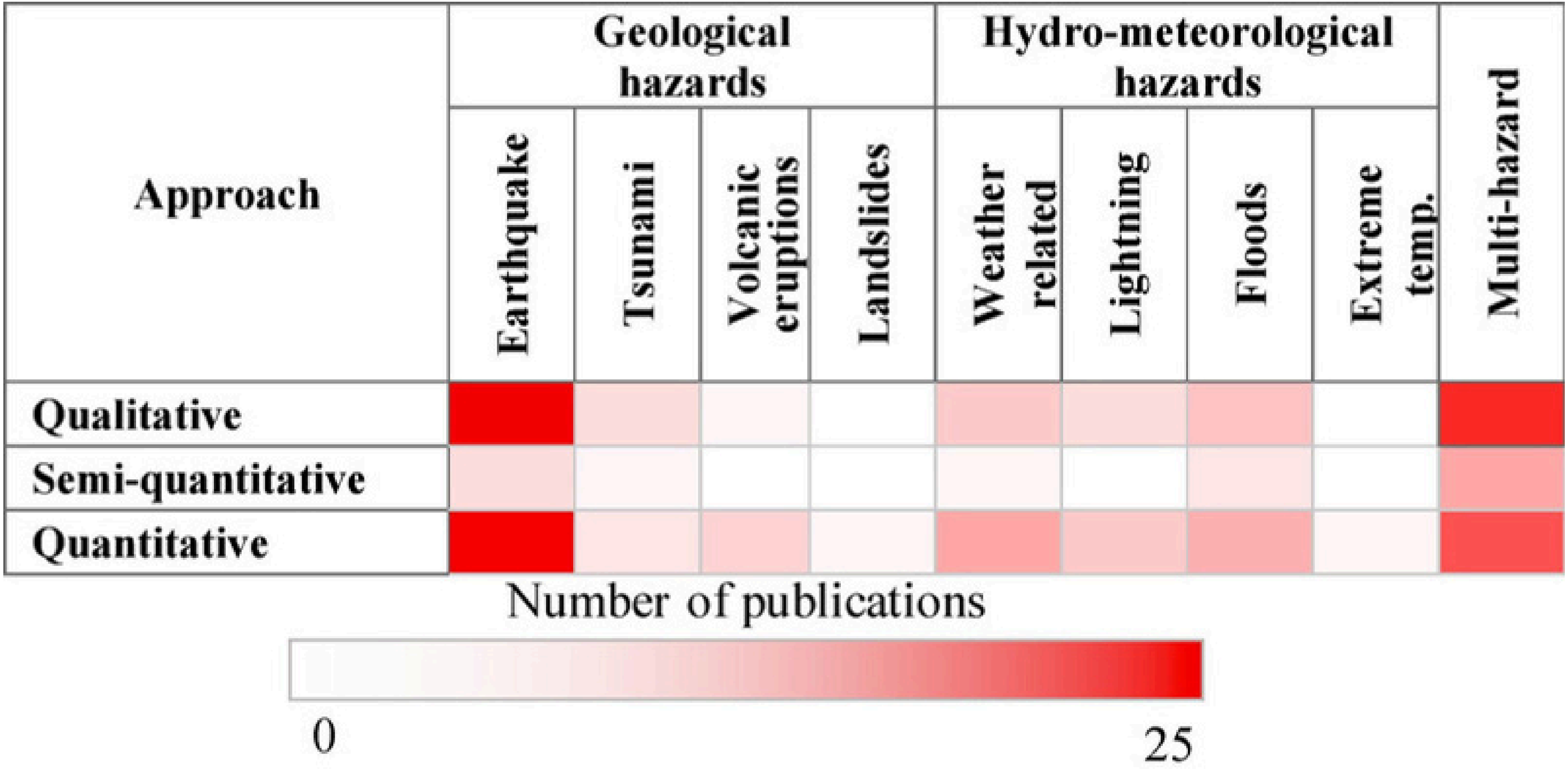

Approach
Geological hazards
Hydro-meteorological hazards
Earthquake
Tsunami
Volcanic eruptions
Landslides
Weather related
Lightning
Floods
Extreme temp.
Multi-hazard
Qualitative
Semi-quantitative
Quantitative
Number of publications
0
25

Frequency

Area of Impact

Damage

Frequency

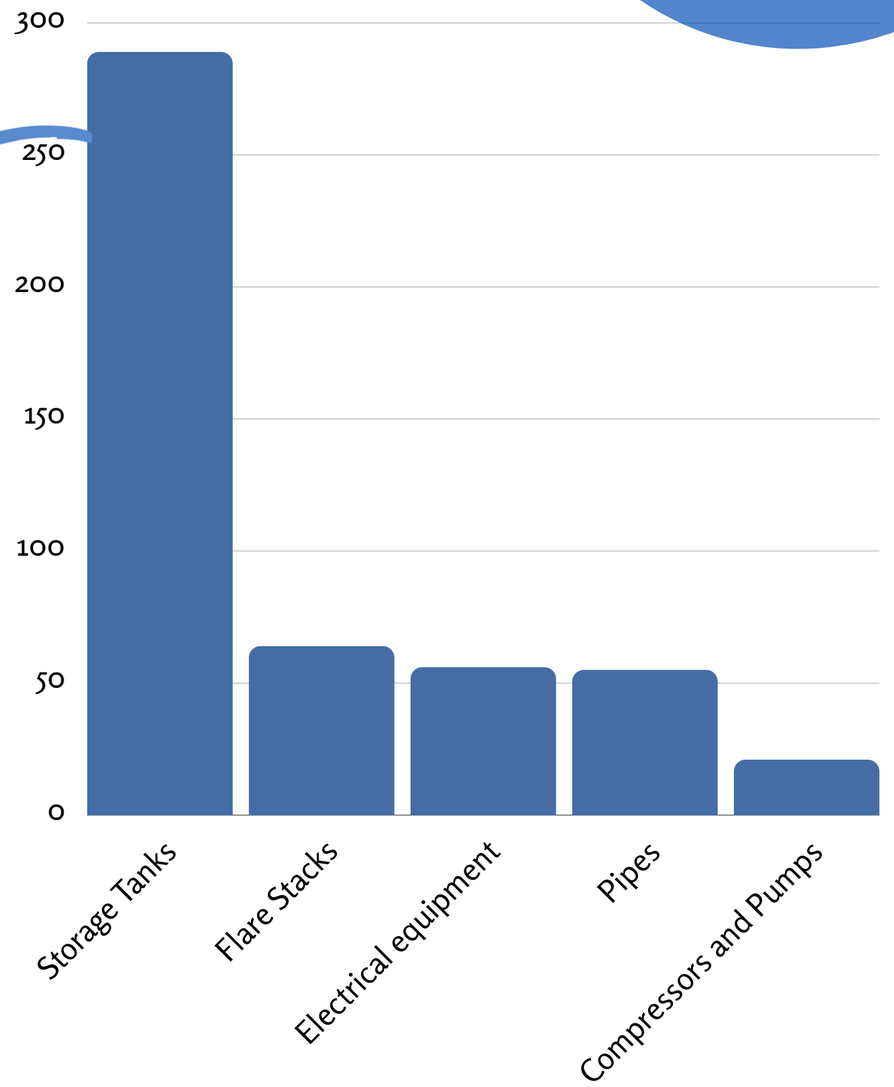
Area of Impact

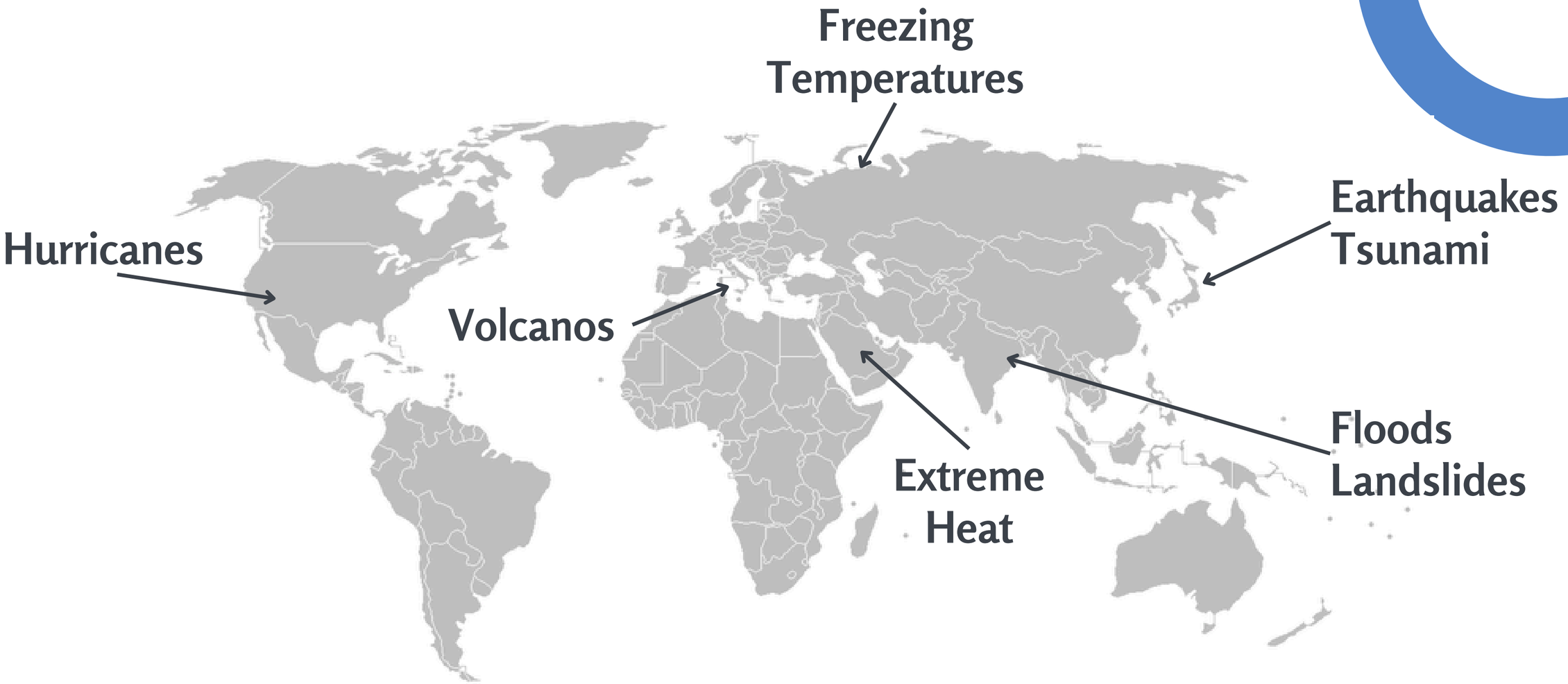
Damage

Frequency

Area of Impact

Damage





Sourrounding enviroment, Social and Psicological Effects, Politics...