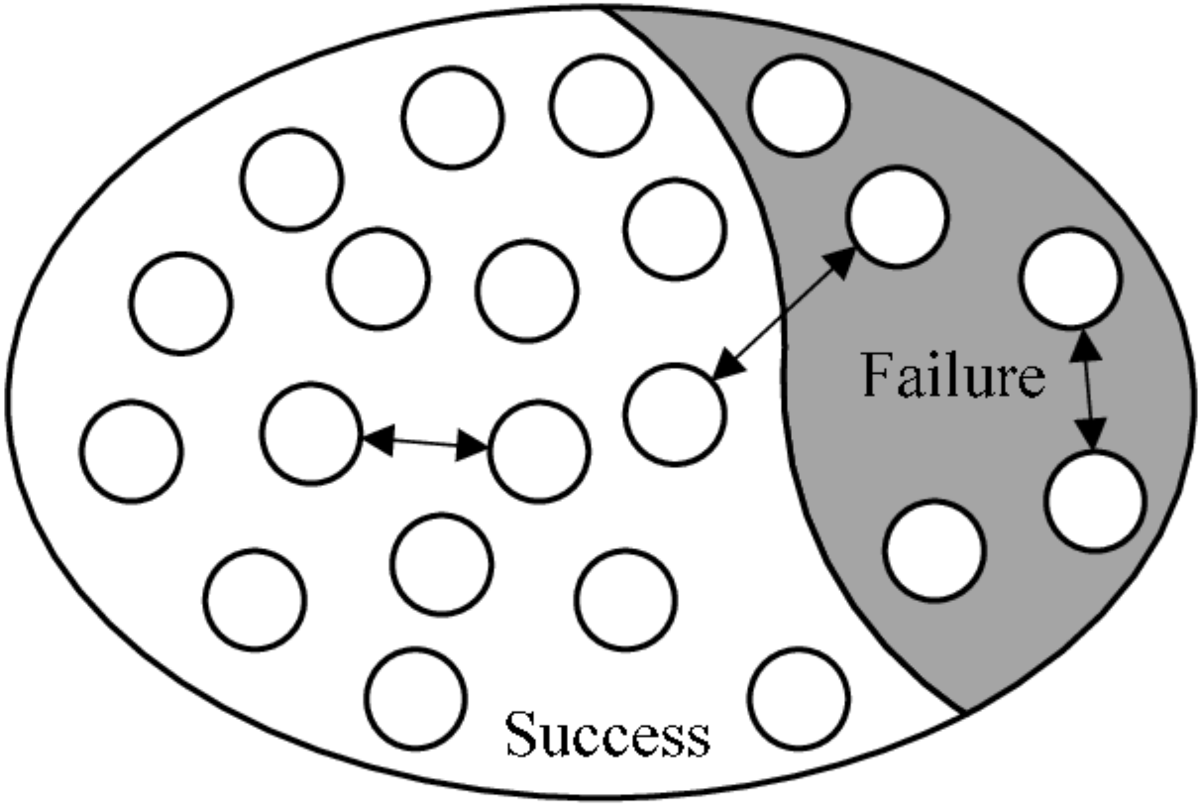
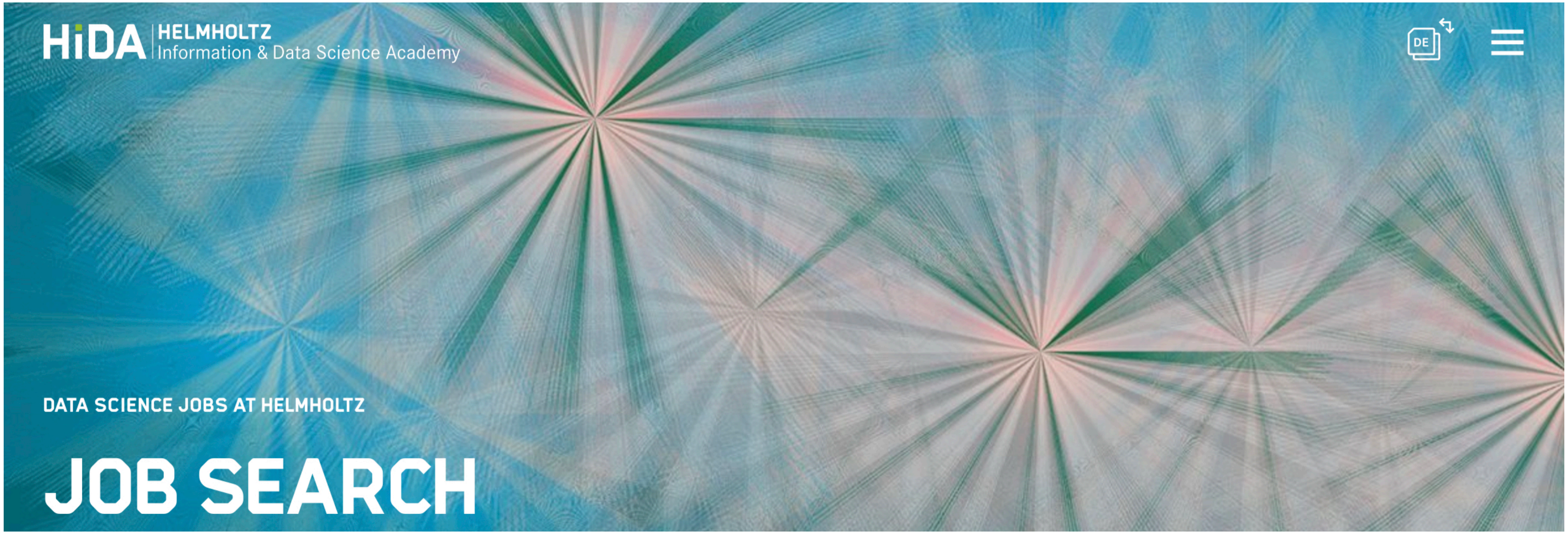
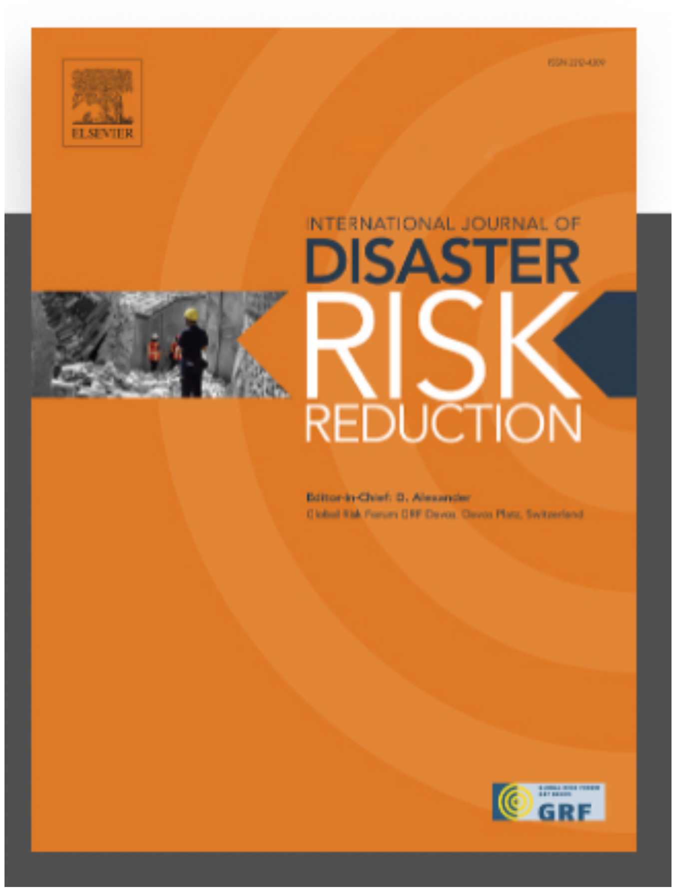
Multi-hazard and multi-risk decision-support tools as a part of participatory risk governance:



Komendantova N, Mrzyglocki R, Mignan A, Khazai B, Wenzel F, Patt A, Fleming K
International Journal of Disaster Risk Reduction, 8:50-67(June 2014) 8 (Published online16 January 2014).



Originally published as: Multi-hazard and multi-risk decision-support tools as a part of participatory risk governance: Feedback from civil protection stakeholders. - International Journal of Disaster Risk Reduction, 8, p. 50-67.



This journal welcomes contributions that support and advance the UN's sustainable development goals

The International Journal of Disaster Risk Reduction (IJDRR) is the journal for researchers, policymakers and practitioners across diverse disciplines: earth sciences and their implications; environmental sciences; engineering; urban studies; geography; and the social sciences. IJDRR publishes fundamental and applied research, critical reviews, policy papers and case studies with a particular focus on multi-disciplinary research that aims to reduce the impact of natural, technological, social and intentional disasters. IJDRR stimulates exchange of ideas and knowledge transfer on disaster research, mitigation, adaptation, prevention and risk reduction at all geographical scales: local, national and international.

Key topics:

•multifaceted disaster and cascading disasters
•the development of disaster risk reduction strategies and techniques
•discussion and development of effective warning and educational systems for risk management at all levels
•disasters associated with climate change
•vulnerability analysis and vulnerability trends
•emerging risks
•resilience against disasters

.The journal particularly encourages papers that approach risk from a multi-disciplinary perspective, in particular SDG 5 (Gender Equality)

Historical records show that economic losses from disasters have increased :

150 Biliões de Euros - 1950 to 1959

375 Biliões de Euros - 1990 to 1999

Autor: Redacción Digital | internet@granma.cu
2 de noviembre de 2020 15:11:40

(Munich RE,46 2000)

Non-economic losses, such as human lives, are much more difficult to assess and they are not included in the majority of data bases.
None the less there is ample evidence in the literature that the number of people who are directly or indirectly affected by disasters will continue to increase.

(Arnold et al.,2006; 50 Bilham, 2009; Daniell et al., 2011; Hoyois and Guha-Sapir, 2003; World Bank 51 2010).

A **hazard** is a potential source of harm. Substances, events, or circumstances can constitute hazards when their nature would allow them, even just theoretically, to cause damage to health, life, property, or any other interest of value. The probability of that harm being realized in a specific *incident*, combined with the magnitude of potential harm, make up its risk, a term often used synonymously in colloquial speech.

Many regions of the world are not simply subject to single hazards, but maybe impacted up on by multiple hazards, which may also be correlated.

Centenas de pessoas esperam a chegada da ajuda humanitária da ONU para receber comida em Damasco: Guerra civil na Síria já matou cerca de meio milhão de pessoas (foto: Getty Images)

Leia mais em: https://guiadoestudante.abril.com.br/blog/atualidades-vestibular/guerra-na-siria-saiba-quais-sao-as-forcas-envolvidas-no-conflito/

Conjoint disasters and other cascading effects yield higher direct losses, such as damage to infrastructure, as well as higher indirect losses, such as business interruption.

Existing risk assessment methods integrate large volumes of data and sophisticated analyses, as well as different approaches to risk quantification.

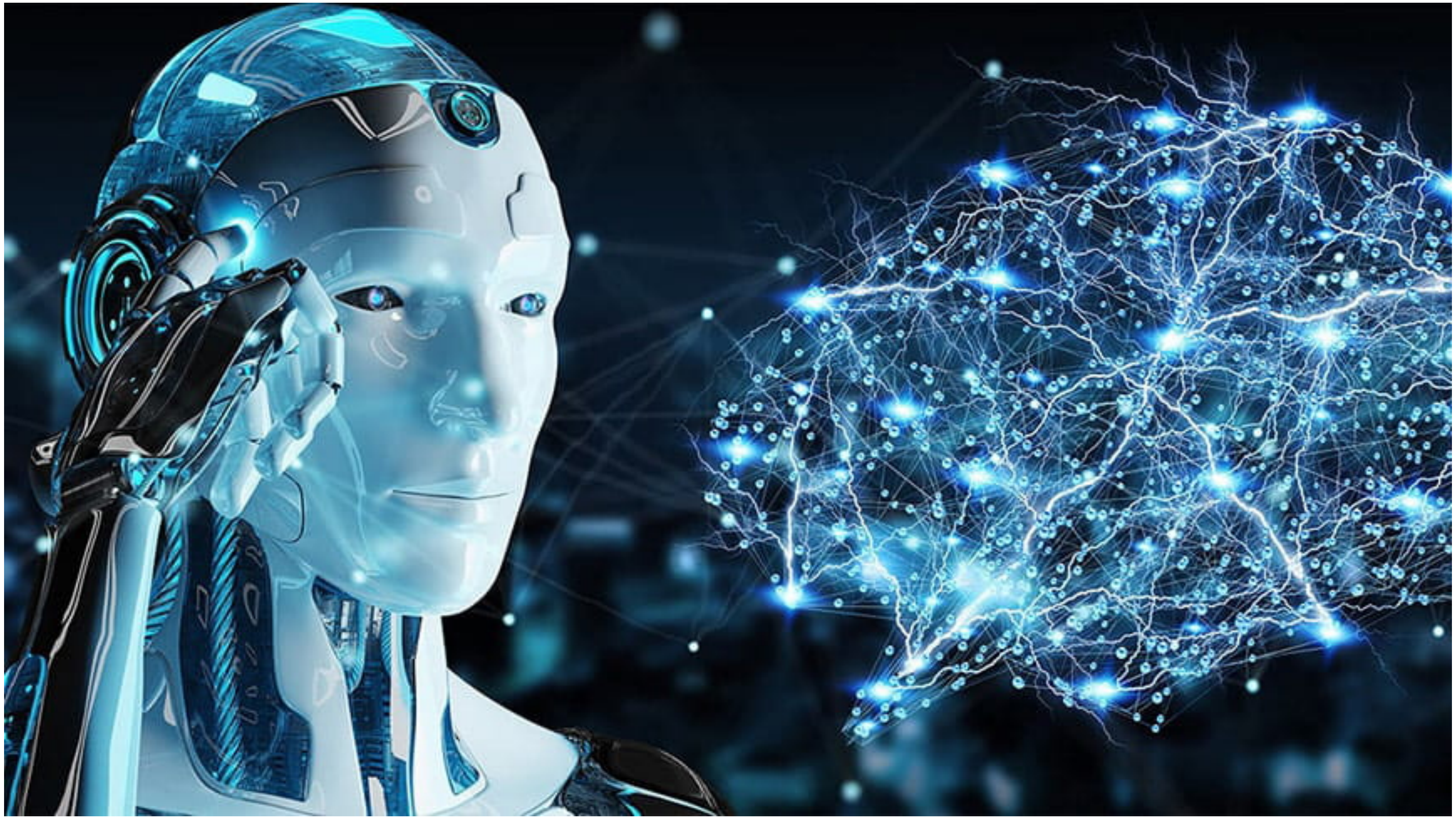
However, the key question is why do losses from natural disasters continue to grow if our scientific knowledge on multi-risk increases ?

(Whiteetal.,2001).

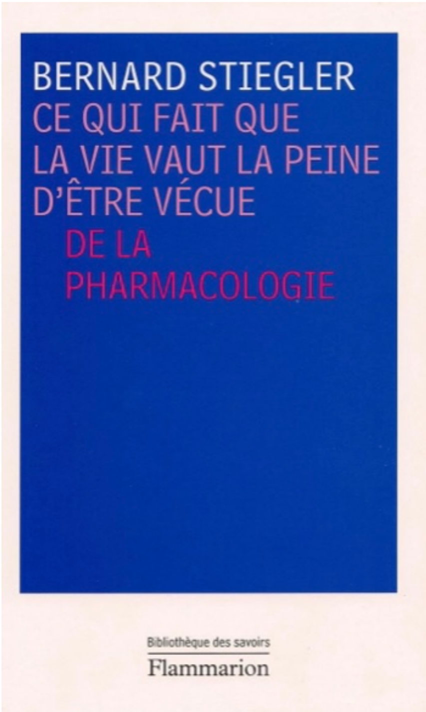
To be able to understand this question, we need to examine also the frame works employed in the field of risk management, as well as the interactions between science and practice interms of knowledge transfer and the applicability of results.

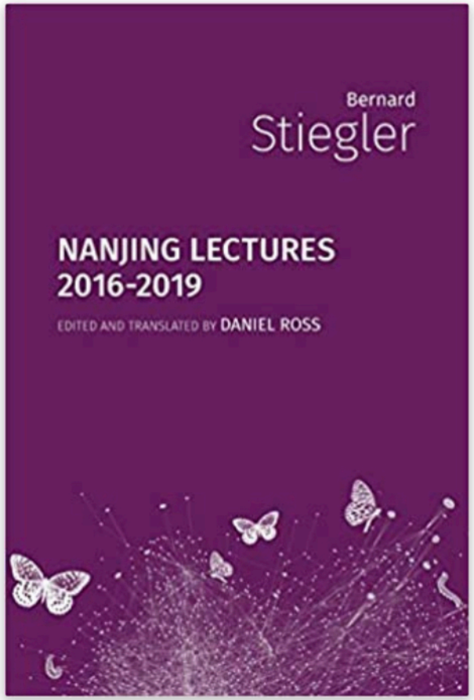
The success ful implementation of disaster risk reduction options and strategies demand not only comprehensive risk assessment schemes, but also an appropriate mechanism to communicate and transfer knowledge on risk and its under lying drivers to the various stakeholders involved in the decision making process.

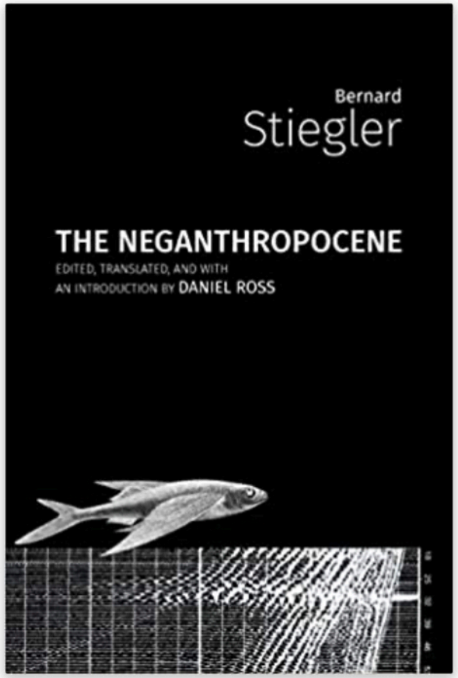
Multi-risk assessment tools have the potential to support decision-makers and to provide them with information on mitigation measures.These tools can influence the perceptions of stake holders in terms of the probabilities of hazards and their impacts. But this is a double–sided communication process, as the feedback from stake holders ´influences the usability of the tools and the implementation of recommendations provided by the geo sciences, sociology and economics.



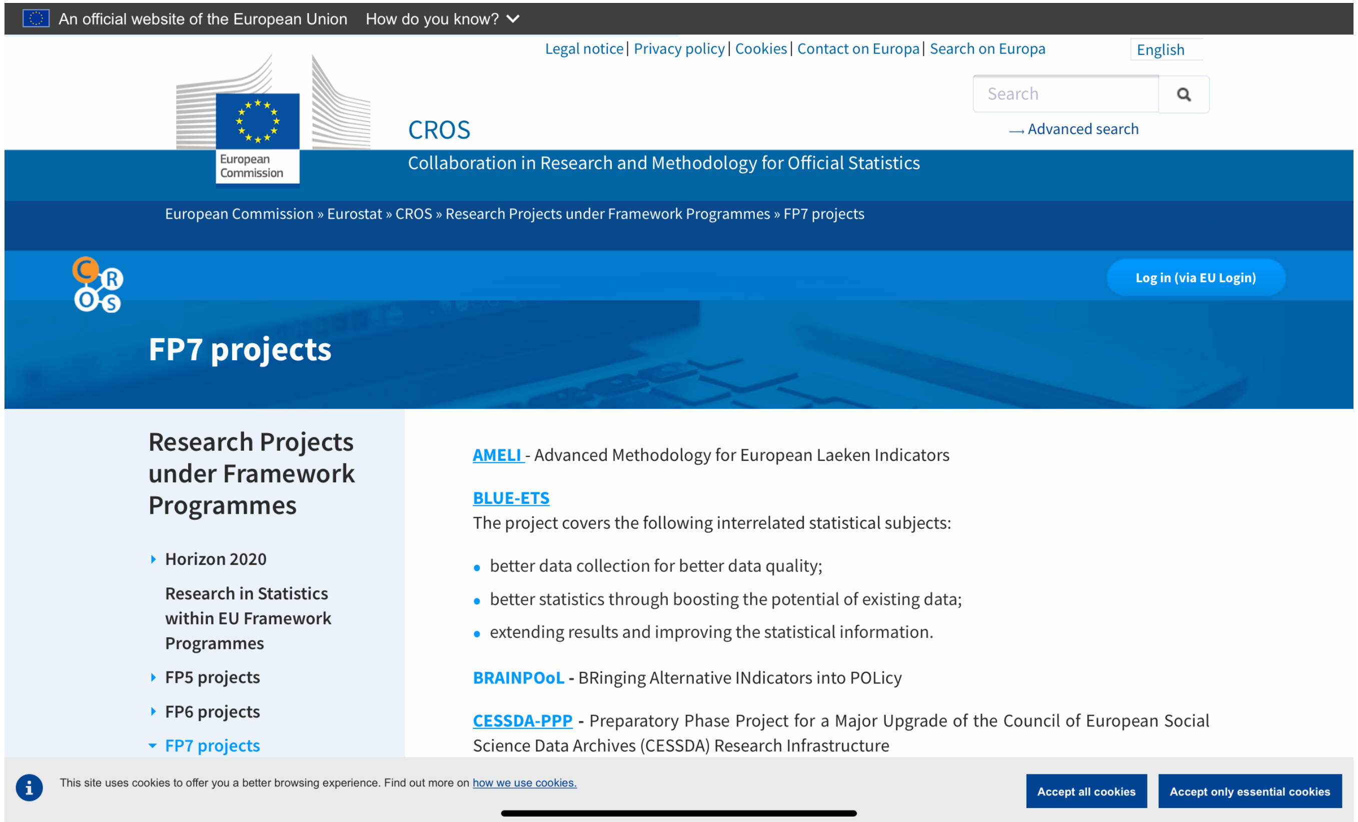
That is why feedback and perceptions of the usability of these models from the side of stake holders are extremely important to the process of communication from science to policy and vise versa. So far, how ever, the literature on the topic of how stake holders perceive the usability of multi-risk models is very limited.







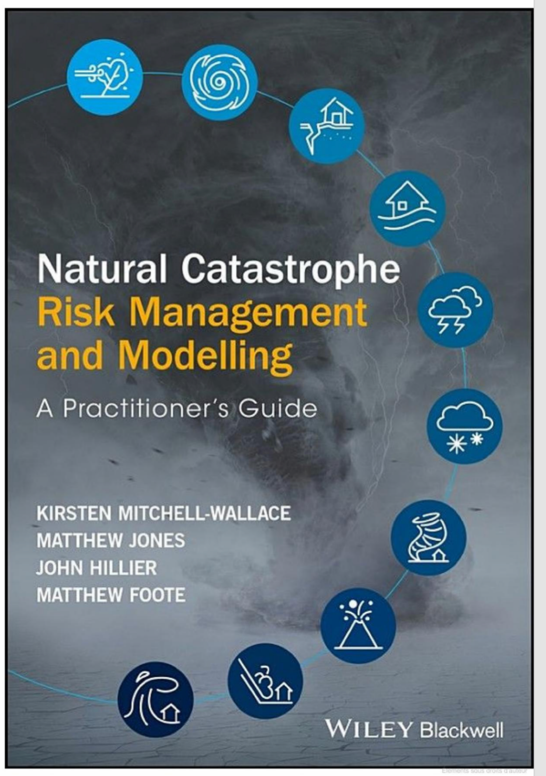
The aim is to identify the perceptions of stake holders to the value of two complementary decision-making tools developed with in the context of the EUFP7 project New Multi-Hazard and Multi-Risk Assessment Methods for Europe (MATRIX):



Therefore, MATRIX set out to develop concepts, methods, frameworks and tools for dealing with risk assessment within a multi-hazard and risk environment. The focus was on the hazards that most affect Europe, namely earthquakes, landslides, volcanos, tsunamis, wild fires, storms and fluvial and coastal flooding. Interactions at all the different levels were considered, such as cascading events and time dependency in vulnerability. The resulting products were applied at three test cases: Naples, Italy, the French West Indies, and Cologne, Germany. Considerable interaction with end-users was also undertaken, including identifying biases at the individual and institutional level which may hinder employing a multi-type framework for risk governance

(1) A generic probabilistic frame work that implements hazard correlations in a comprehensive manner (Mignan,2013)
(2) ,An evaluation methodology based on the concept of the risk matrix to incorporate expert knowledge through stakeholder interactions in to multi-hazard scenario development developed by B.Khazai at the Karlsruhe Institute of Technology.

1

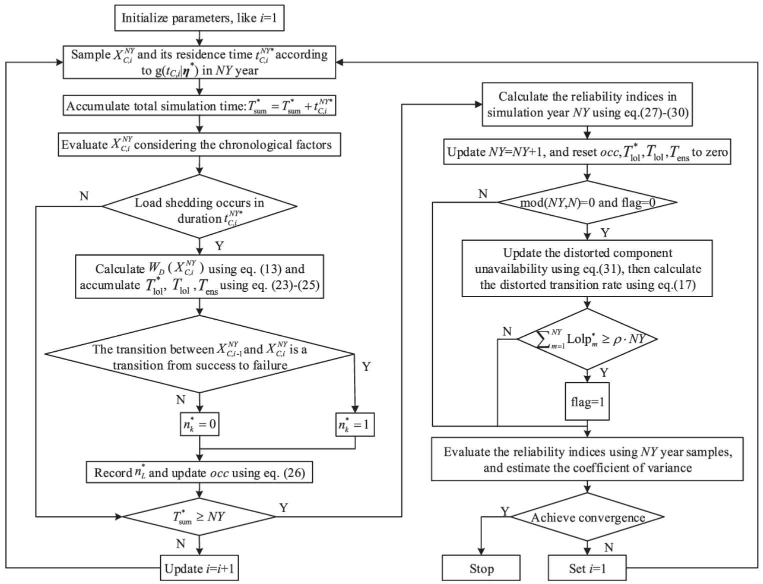


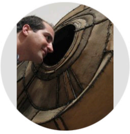
6.3.3 Open Modelling and Open Architectures

Dicke Whitaker

In the past few decades, the use of catastrophe models in the (re)insurance industry has grown significantly. Many models have been developed for a significant number of perils and regions and the complexity and detail of the models, as well as the computing power required to run them, have increased many times. Today the (re)insurance market expends significant resources on licensing and operating catastrophe models. These are predominantly sourced from the two market-leading firms; their proprietary software largely is installed as an in-house platform. Typically, public information is limited on these products, leading to a perception of them being 'black boxes' even if significant information is provided in (proprietary) user documentation. This forces comparisons to be made by organizations holding multiple licences (e.g. WillisRe, 2007; Waisman, 2015).

Non-proprietary risk assessment software and publicly documented risk assessment software have existed for a number of years, such as HAZUS (i.e. http://www.fema.gov/hazus). It is not uncommon for academics to develop entry-level catastrophe models or publish methodologies (e.g. Powell *et al.*, 2005; Varghese and Rau-Chaplin, 2013; Punge *et al.*, 2014), but they have either tended to be subsumed into larger products (e.g. Hailcalc Europe into RMS) or the research is not implemented in the first place (e.g. the MATRIX project (Mignan, 2013)).





Bijan Khazai

Senior Research Scientist, Center for Disaster Management and Risk Reduction Technologies, Karlsruhe Institute of Technology
Verified email at kit.edu

Urban Risk   Decision Support   Socio-economic Impacts   Disaster Vulnerability   Seismic Slope Stability

The Karlsruhe Institute of Technology (KIT; German: *Karlsruher Institut für Technologie*) is a public research university that is one of the largest educational institutions and the largest research institution by funding in Germany. KIT was created in 2009 when the University of Karlsruhe (*Universität Karlsruhe*), founded in 1825 as a public research university and also known as the "Fridericiana", merged with the Karlsruhe Research Center (*Forschungszentrum Karlsruhe*), which had originally been established in 1956 as a national nuclear research center (*Kernforschungszentrum Karlsruhe*, or KfK).

KIT is a member of the TU9, an incorporated society of the largest and most notable German institutes of technology. As part of the German Universities Excellence Initiative KIT was one of three universities which were awarded excellence status in 2006. In the following "German Excellence Strategy" KIT was awarded as one of eleven "Excellence Universities" in 2019. KIT is among the leading technical universities in Germany and Europe and established the first German faculty for computer science in 1972. According to different bibliometric rankings, KIT is the German university with the strongest research in engineering and natural sciences.

Post-disaster recovery dilemmas: challenges in balancing short-term and long-term needs for vulnerability reduction
JC Ingram, G Franco, C Rumbaitis-del Rio, B Khazai
Environmental science & policy 9 (7-8), 607-613

Evaluation of factors controlling earthquake-induced landslides caused by Chi-Chi earthquake and comparison with the Northridge and Loma Prieta events
B Khazai, N Sitar
Engineering geology 71 (1-2), 79-95

Multi-hazard and multi-risk decision-support tools as a part of participatory risk governance: Feedback from civil protection stakeholders
N Komendantova, R Mrzyglocki, A Mignan, B Khazai, F Wenzel, A Patt, ...
International Journal of disaster risk reduction 8, 50-67

The CATDAT damaging earthquakes database
JE Daniell, B Khazai, F Wenzel, A Vervaeck
Natural Hazards and Earth System Sciences 11 (8), 2235-2251

SYNER-G: systemic seismic vulnerability and risk assessment of complex urban, utility, lifeline systems and critical facilities: methodology and applications
K Pitilakis, P Franchin, B Khazai, H Wenzel
Springer

Investigation of superstorm Sandy 2012 in a multi-disciplinary approach
M Kunz, B Mühr, T Kunz-Plapp, JE Daniell, B Khazai, F Wenzel, ...
Natural Hazards and Earth System Sciences 13 (10), 2579-2598

Review of literature on decision support systems for natural hazard risk reduction: Current status and future research directions
JP Newman, HR Maier, GA Riddell, AC Zecchin, JE Daniell, AM Schaefer, ...
Environmental Modelling & Software 96, 378-409

Assessment of seismic slope stability using GIS modeling
B Khazai, N Sitar
Geographic Information Sciences 6 (2), 121-128

Open space suitability analysis for emergency shelter after an earthquake
J Anhorn, B Khazai
Natural Hazards and Earth System Sciences 15 (4), 789-803

Tourism Recovery Scorecard (TOURS)–Benchmarking and monitoring progress on disaster recovery in tourism destinations
B Khazai, F Mahdavian, S Platt
International Journal of Disaster Risk Reduction 27, 75-84

By: Bijan Khazai

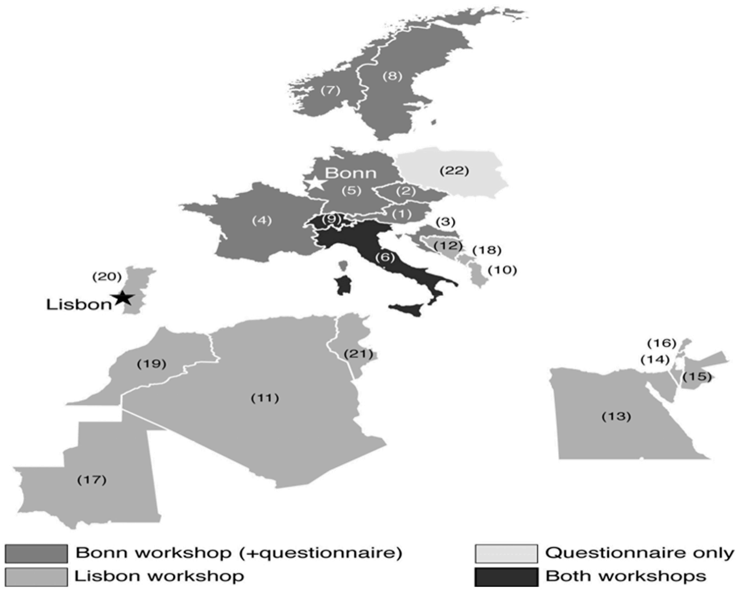
In an emergency situation shelter space is crucial for people affected by natural hazards. Emergency planners in disaster relief and mass care can greatly benefit from a sound methodology that identifies suitable shelter areas and sites where shelter services need to be improved. A methodology to rank suitability of open spaces for contingency planning and placement of shelter in the immediate aftermath of a disaster is introduced. The Open Space Suitability Index uses the combination of two different measures: a qualitative evaluation criterion for the suitability and manageability of open spaces to be used as shelter sites and another quantitative criterion using a capacitated accessibility analysis based on network analysis. For the qualitative assessment implementation issues, environmental considerations and basic utility supply are the main categories to rank candidate shelter sites. A geographic information system is used to reveal spatial patterns of shelter demand. Advantages and limitations of this method are discussed on the basis of an earthquake hazard case study in the Kathmandu Metropolitan City. According to the results, out of 410 open spaces under investigation, 12.2% have to be considered not suitable (Category D and E) while 10.7% are Category A and 17.6% are Category B. Almost two-thirds (59.55%) are fairly suitable (Category C).

Back to this work : a first attempt to collect and to integrate feedback of stakeholders from civil protection authorities in to decision-making tools which include aspects of multi-hazard and multi-risk. The feedback was gained during two workshops, in Bonn (July2012) and in Lisbon (October2012), and from a 100 questionnaire distributed prior to the first workshop. The research with in this worken compasses three overarching questions:

A- How do stakeholders perceive multi-hazard and multi-risk situations and what are their requirements for multi-risk assessment tools?

B- How do stakeholders perceive the decision-making process for the mitigation of multi-risk and their perceptions on the usability of decision-making tools?

C- Is there a difference in the resulting perceptions between stakeholders (based on practice) and academia (based on more 110 theoretical considerations)?



This short review especially high lights the fact that decision-making under multi-risk is an ascent field. Feedback from stake holders on newly developed multi-risk tools in participatory process is greatly needed to avoid a **dichotomy between science and practical applications.**

Definitions of multi-risk assessment:
Risk assessment includes hazard assessment, followed by estimations of the vulnerability and values of the elements at risk (or exposure), all leading to the computation of risk as a function of hazard, vulnerability and exposure

(Varnes,126 1984).

The term"natural hazard" refers to the" natural processor phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage "

(UNISDR,2009).

Risk is defined as" expected losses of lives, persons injured, property damages and economic activities disrupted due to a particular hazard for a given area and reference period "

(WMO,1999).

Another definition of risk is " the combination of the probability of an event and its negative consequences "

(UNISDR,2009).

In any case, a definition of risk must also include the interaction of hazards and the vulnerability of the affected area, especially the built environment.

Definitions developed by the European Commission extend the previous definitions by incorporating the terms **"exposure" and "vulnerability"**

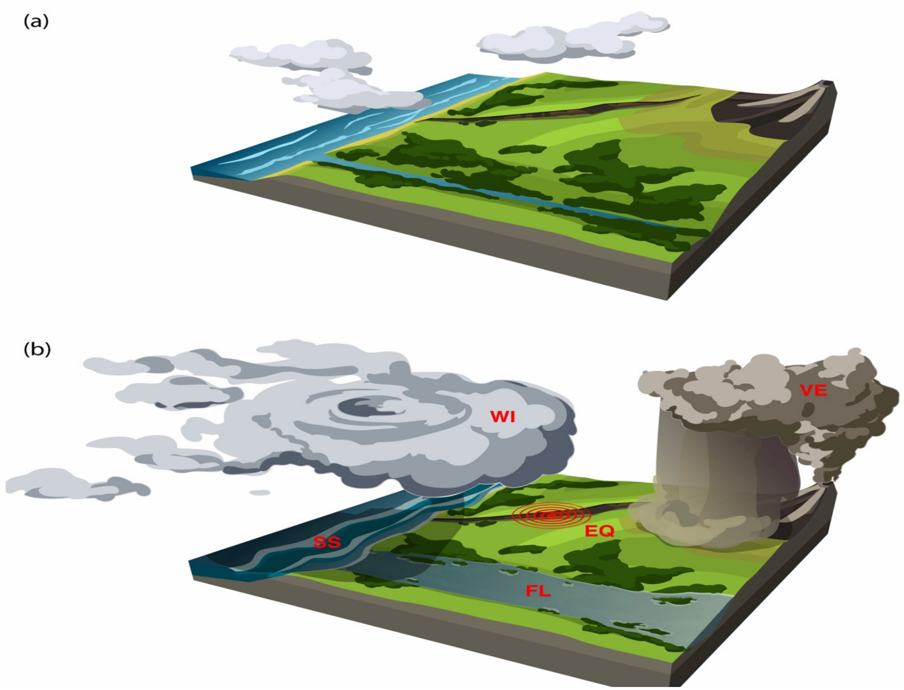
(COM, 2010 a).

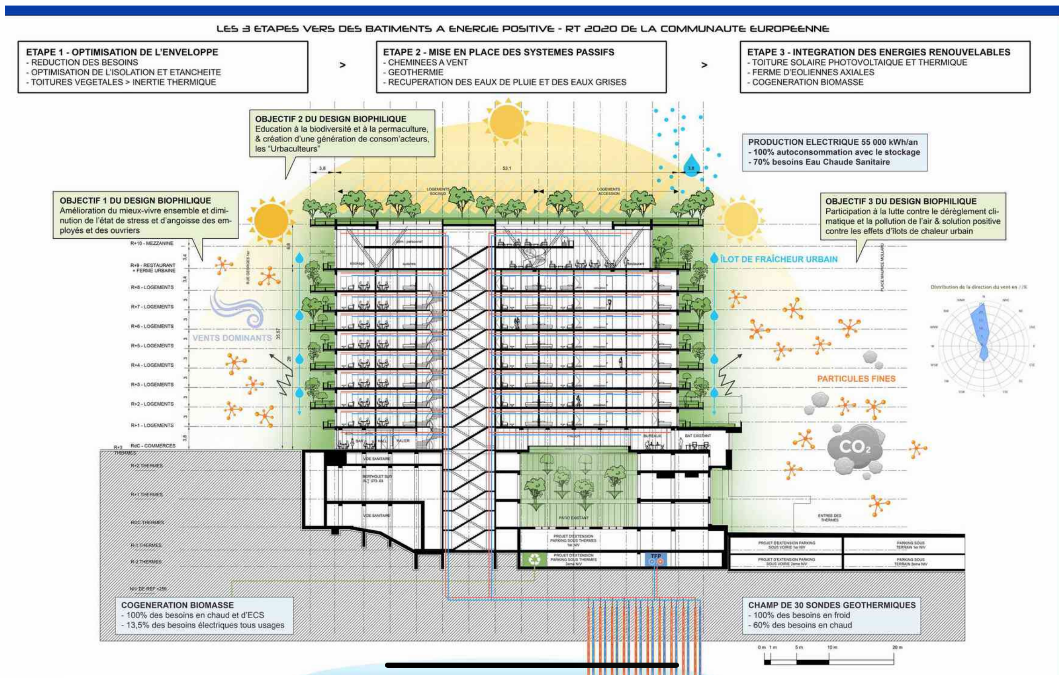
This foresees that an event of the same magnitude. can have a different impact, dependent upon the vulnerability and exposure of a given population and the associated elements, thus also involving the need to take in to consideration preparedness and preventive measures.

The definition of risk is also closely connected with the definition of uncertainty, as the term “probability” already it self implies aleatory uncertainties.

Risk can also be understood as “ the effects of uncertainty on objectives ” which appear as a “combination of the consequences of an event and the associated likelihood of occurrence”

(ISO Guide 73: 2009)





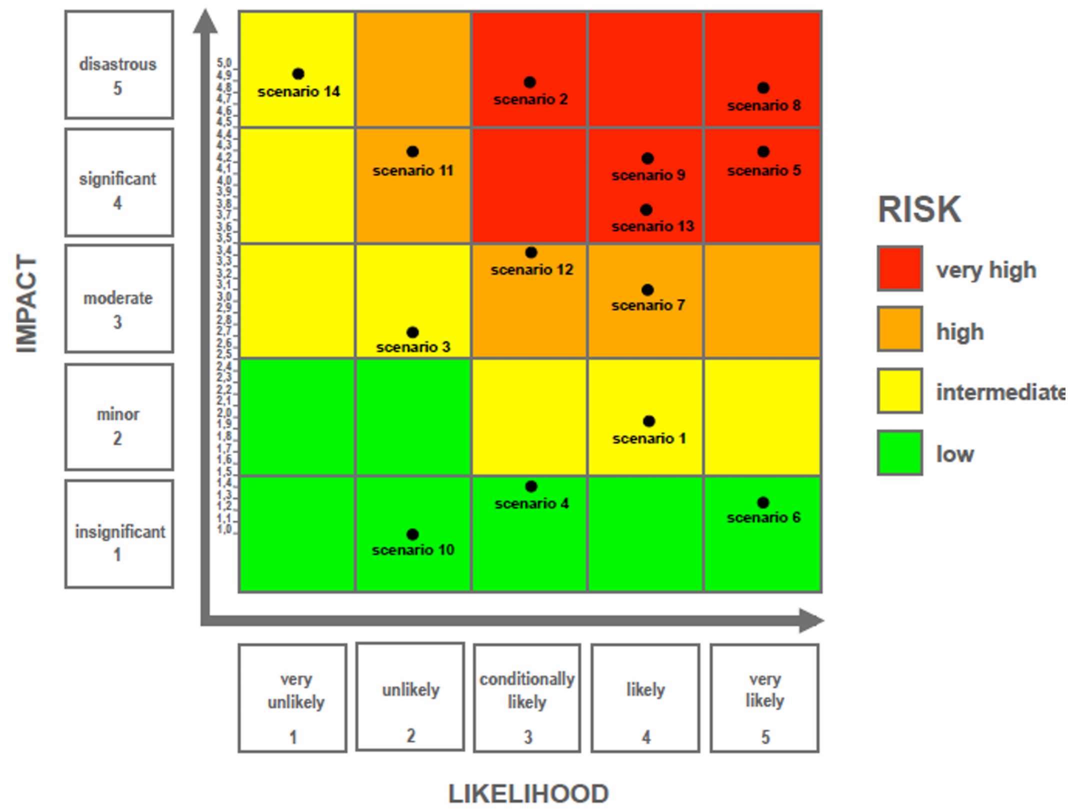
It is there fore important to understand such uncertainties when it comes to the development of decision-making models and tools for the purposes of civil protection.

The purpose of multi-risk assessment is there fore to establish a ranking of different types of risk, taking in to account possible conjoint and cascade effects.

Multi-risk assessment is a relatively new field, until now developed only partially by experts with different backgrounds such as engineering, statistics or various fields of geosciences.

Currently, there is no clear definition of“multi-risk”, neither in science, nor in practice

(COM, 2010 a; Kappes et al.,2012).



There are essentially two ways to approach multi-risk.The first considers the different types of hazards and vulnerabilities of a region and combines the results of various single risk layers into a multi-risk concept

(Grünthal et al.,2006).

This approach provides an over view of multiple risks, but neglects the interactions between the hazards and vulnerability. The second one considers the risk arising from multiple hazardous sources and multiple vulnerable elements coinciding in time and space

(Di Mauro et al.,2006).

Distinction between conjoint and cascading events must be made here. **Conjoint events are when a series of parallel adverse events are generated by different sources, for example a wind storm occurring at the same time as an earthquake**

(Di Mauro et al., 2006).

Cascading events on the other hand are when an initial event triggers a subsequent event or series of events, for example an earthquake that triggers a land slide or a tsunami

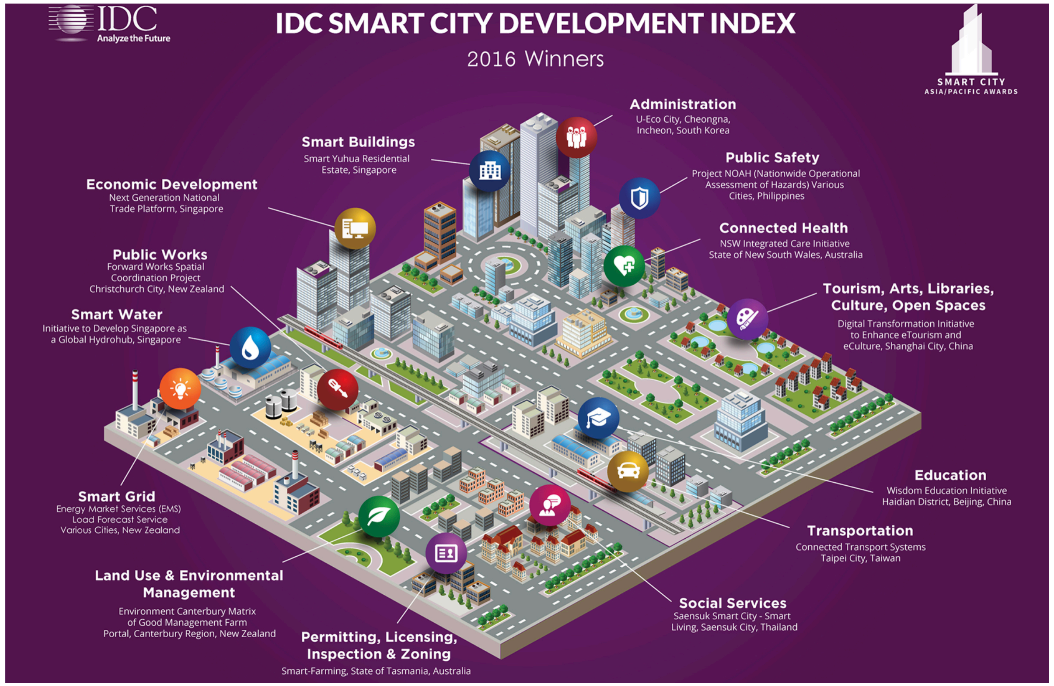
(e.g.,170 Marzocchi et al., 2012).

Major Quake Shakes Acapulco, Mexico City
At least one death was reported after a 7.1 magnitude temblor struck on Tuesday night. About **1.6 million were left without power.**

Published Sept. 7, 2021
Updated Sept. 22, 2021

The first approach considers more than one type of hazard, but it ignores the spatial and temporal relation ships between the hazards and other elements of the risk chain. For example, in the Cities Project in Australia

(Granger, 1999)



A number of urban and regional areas were assessed for a widerange of geo-hazards, however, the various interactions that may arise between hazards were not part of this program. Similarly,in the German Research Network Natural Disasters Project, the city of Cologne was assessed for earthquakes, wind storms and river floods separately, and while losses interms of monetary values arising from each hazard were plotted together against the probability of occurrence to allow a comparison,the possible interactions between them and the effect this has on the final risk were not considered, nor were the associated uncertainties

(Grünthal et al., 2006).

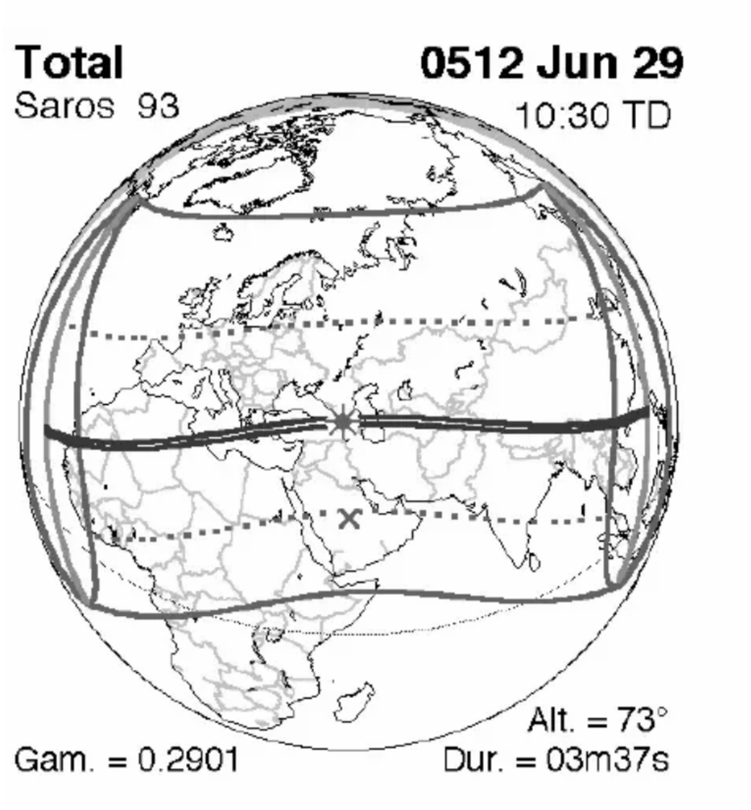
By contrast, the second type explicitly considers spatial and temporal interactions between different hazards and their subsequent risk.

An example is the NaRaS EU project for the Casal nuovo municipality in the province of Naples in Italy.

This municipality is located just 13km away from the crater of the mount Vesuvius volcano and is exposed to several kinds of hazards, such as the Vesuvius volcano, active faults in the Apolline chain (tectonic source area of the damaging 1930 and 1980 Irpinia earthquakes),**as well as the presence of industrial land fills.**

A study supported by the local government, who was interested in the identification of the most dangerous hazards and the most effective way off inancing risk mitigation measures, found that volcanic risks significantly over whelm all others, but also that the **risks associated with volcanic processes and the effects these have on industry maybe underestimated if the interactions between them is not considered.**

(Marzocchi et al.,2012)



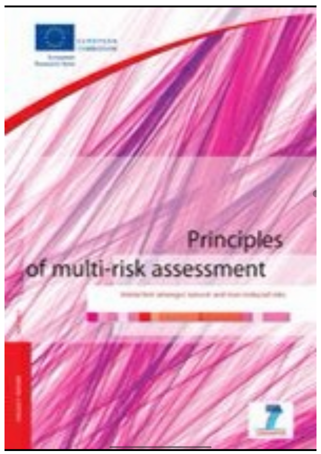
Principles of multi-risk assessment
Interaction amongst natural and man-induced

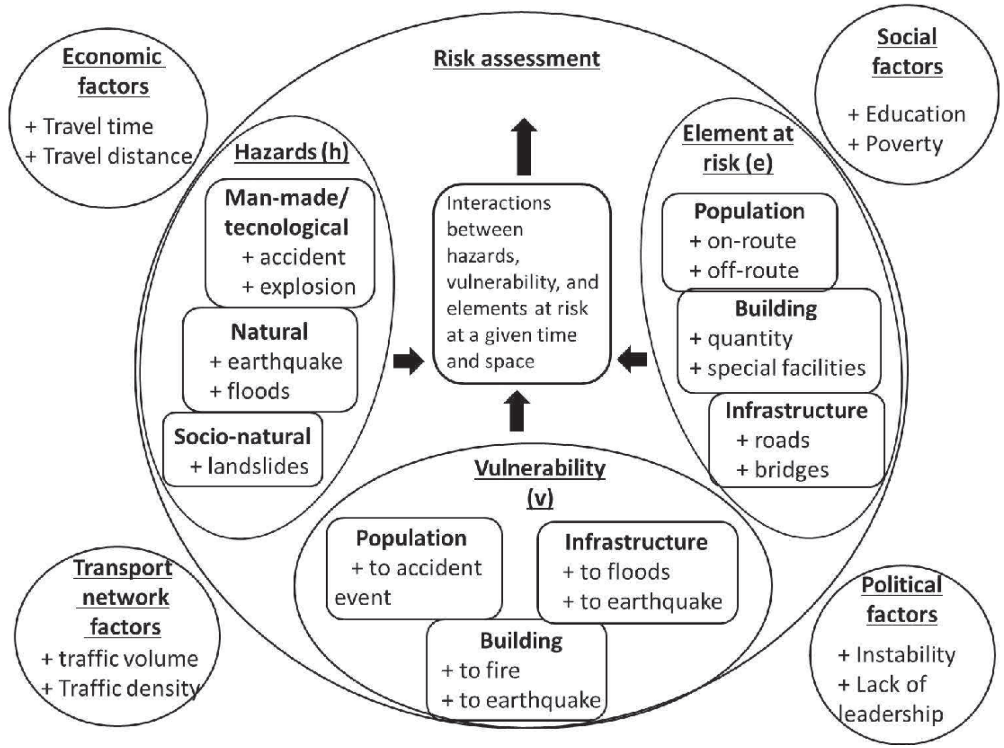
Publication metadata

Multi-risk evaluation is a relatively new field, until now developed only partially by experts with different backgrounds.
The EC FP6 NARAS project initiated some consideration and reflexion on this topic.

As mentioned by Durham, a joint analysis and quantification of all the anthropogenic and natural risks which can affect a territory (multi-risk approach) is a basic factor for development of a sustainable environment and land use planning as well as for competent emergency management before and during catastrophic events.

This is the aim of this publication that will present ideas and concepts: -report the principles and rationales that stand behind a procedure for multi-risk assessment; -provide a description of the most advanced procedures generally adopted to estimate individually natural and anthropogenic risks representing major threats for Southern Europe; -tackle directly the problem of multi-risk assessment applying innovative procedures and protocols to the case study of a town close to Naples (Casalnuovo).





The reduction of risks can not be only based on scientific knowledge about natural hazards, since risks also have social and psychological dimensions which are in turns haped by political and cultural values

(Assmuth et al., 2010).

Therefore,for the successful implementation of risk mitigation measures,it is necessary to identify these cultural and political factors.

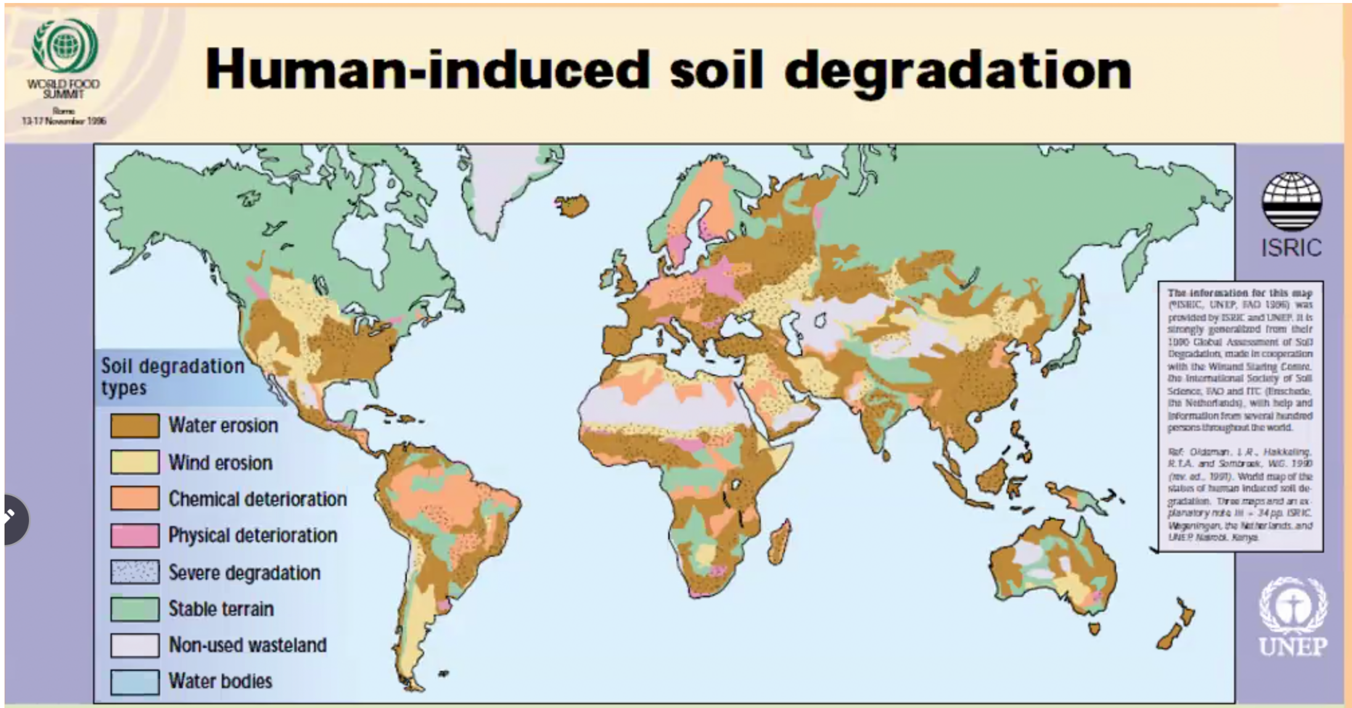
The newly appearing concept of risk governance takes into account these ingredients and emphasizes the role of participation and communication.

It is also crucial to incorporate the experience of stakeholders in to multi-risk assessment models.

Risk governance is concerned with how information is collected, perceived and communicated and follows how management decisions

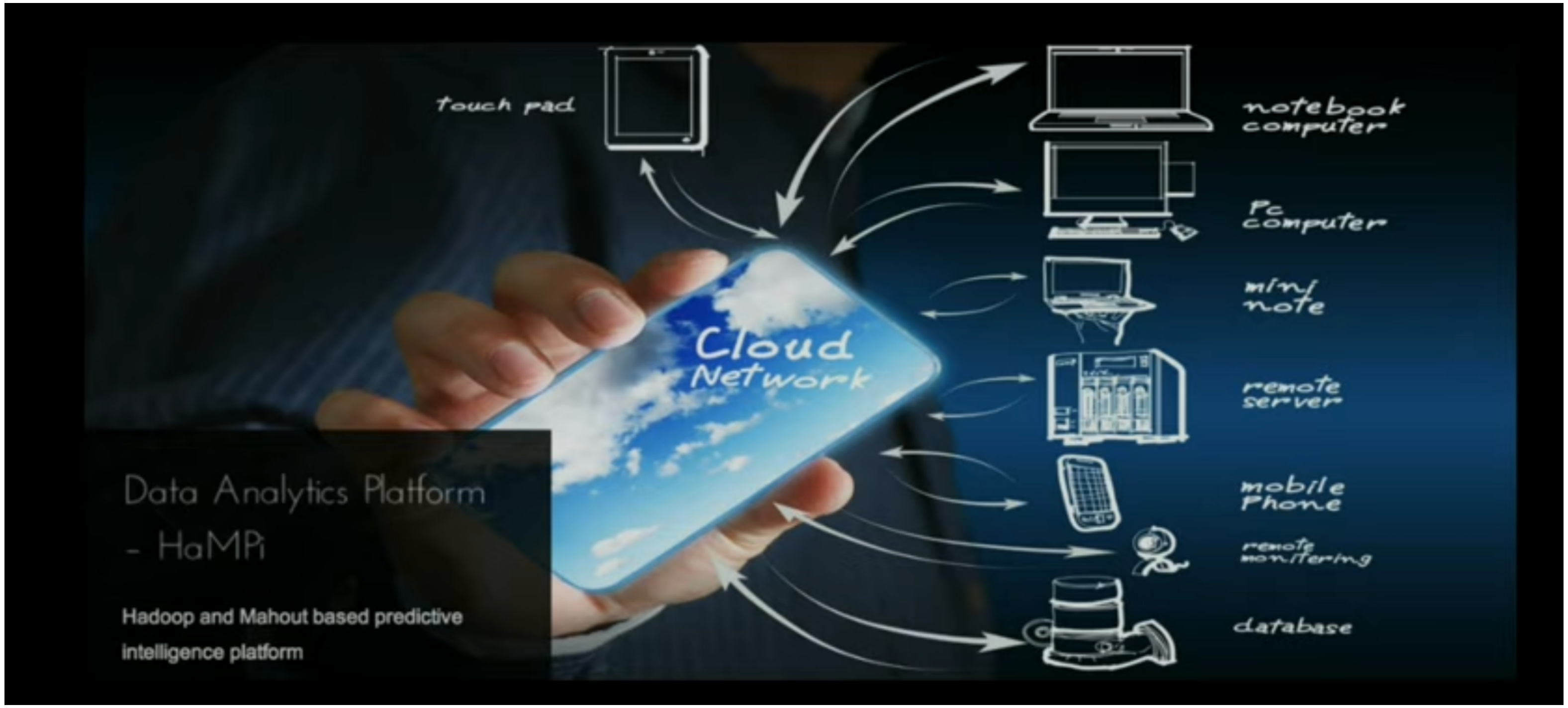
are taken

(IRGC,2005).



In the context of, risk governance, risk communication, not only transfers information on risk, risk management decisions, but it also includes at two-ways process for communicating stakeholder perceptions in shaping the out comes of risk assessments.

Civil protection authorities have started only recently to apply multi-risk assessments for natural and technological disasters.



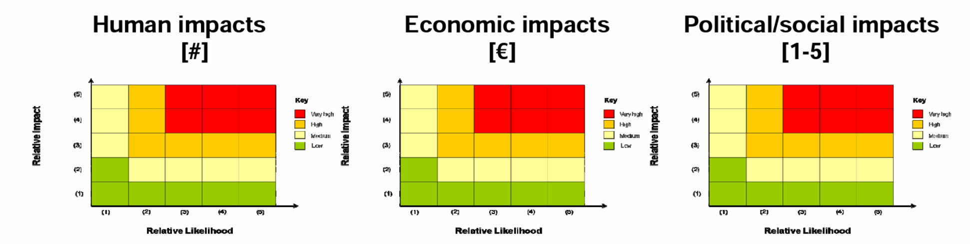
In 2009, the European Commission issue da communication document with a set of measures to be included in to the strategy of the European Community for the mitigation of natural and man-made disasters
(COM,2009).

Amongst other elements, the communication document out lines the need for multi-risk assessment and the need for common guide lines, which will enhance the comparability of risks across Member States and will lead to a common European picture of multi-risk.
The European Union Internal Security Strategy is another milestone to wards the development of multi-risk assessment.
The strategy foresees the establishment of a coherent risk management policy, which will link threats and risk assessment in to decision-making

(COM, 2010 b).

The major aim is to increase the resilience of EU member countries to crises and disasters. Among other risk mitigation measures, the strategy fore sees an "all hazards approach to threat and risk assessment". <u>The Risk Assessment and Mapping Guide lines for Disaster Management</u> focuses on the processes and methods of national risk assessments, as well as on the mapping of risk assessment in to the prevention, preparedness and planning stages

(COM, 2010 a).



Participatory modeling is an important part ofthe risk governance and is the process which allows to take in to consideration notonly facts but also values by asking questions and collecting feedback from stakeholders (Forester,1999).

Therefore,it requires active participation of stakeholders and two-way communication, when feedback is collected and implemented in to risk assessment and decision-support tools. This processis especially useful when facts are uncertain, values are indispute, stakes are high and decisions are urgent.

(Funtowicz and Ravetz,1994).

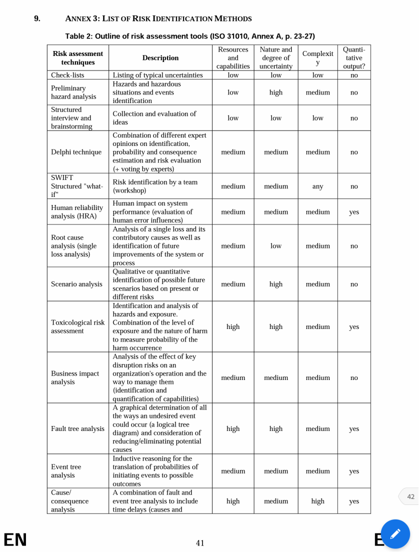

9. ANNEX 3: LIST OF RISK IDENTIFICATION METHODS

Table 2: Outline of risk assessment tools (ISO 31010, Annex A, p. 23-27)

Risk assessment techniques	Description	Resources and capabilities	Nature and degree of uncertainty	Complexity	Quanti-tative output?
Check-lists	Listing of typical uncertainties	low	low	low	no
Preliminary hazard analysis	Hazards and hazardous situations and events identification	low	high	medium	no
Structured interview and brainstorming	Collection and evaluation of ideas	low	low	low	no
Delphi technique	Combination of different expert opinions on identification, probability and consequence estimation and risk evaluation (+ voting by experts)	medium	medium	medium	no
SWIFT Structured "what-if"	Risk identification by a team (workshop)	medium	medium	any	no
Human reliability analysis (HRA)	Human impact on system performance (evaluation of human error influences)	medium	medium	medium	yes
Root cause analysis (single loss analysis)	Analysis of a single loss and its contributory causes as well as identification of future improvements of the system or process	medium	low	medium	no
Scenario analysis	Qualitative or quantitative identification of possible future scenarios based on present or different risks	medium	high	medium	no
Toxicological risk assessment	Identification and analysis of hazards and exposure. Combination of the level of exposure and the nature of harm to measure probability of the harm occurrence	high	high	medium	yes
Business impact analysis	Analysis of the effect of key disruption risks on an organization's operation and the way to manage them (identification and quantification of capabilities)	medium	medium	medium	no
Fault tree analysis	A graphical determination of all the ways an undesired event could occur (a logical tree diagram) and consideration of reducing/eliminating potential causes	high	high	medium	yes
Event tree analysis	Inductive reasoning for the translation of probabilities of initiating events to possible outcomes	medium	medium	medium	yes
Cause/ consequence analysis	A combination of fault and event tree analysis to include time delays (causes and	high	medium	high	yes

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The process of interactions with stake holders leads to an enhanced understanding about points of view, criteria, preferences and trade-offs in decision-making
(Antunes et al.,2006).

The participatory modeling is also used to build consensus among the group of stakeholders on controversial issues, such as for example attribution of weights to different loss parameters under multi-risk scenarios.**First,such models integrating stakeholders perceptions were developed for business management applications**
(Sengeand Sterman,1994).

Recent trends also fore see application of the decision-support models as a problem structuring method and to facilitate group decision support
(Phillips,1990).

Thus, decision-support models become a part of executive debate and dialogue to help avoid judgment biases and systematic errors in decision-making
(Morecroft,1994)

Help in complex decision-making process grounded on human rationality, which can create persistent judgment biases and errors
(Kahnemannand Tversky,1874).

The issue of what input sciences hould provide to policy-making through developed models was discussed already widely in literature
(Jasanoff,1990).

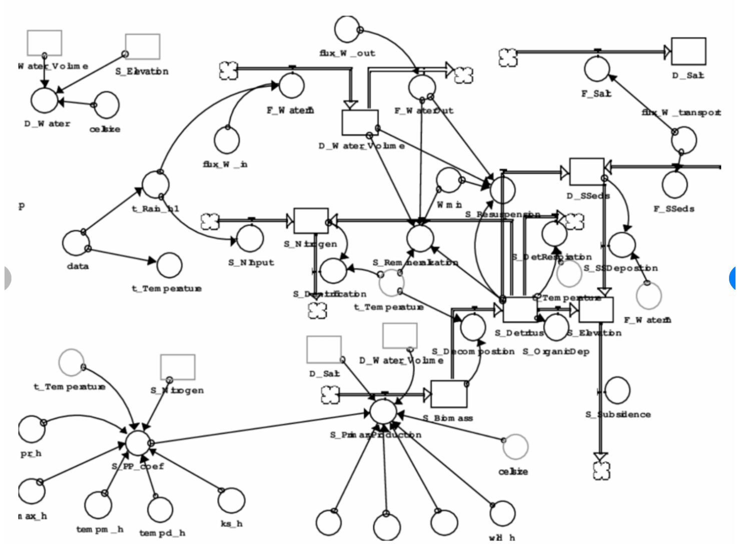
However,it is also known that the process of development of models involves many assumptions and judgments (Korfmacher,1998).

The models,such as **STELLA or the Coast al Ecological Landscape Spatial Simulation (CELSS)**,which integrate the knowledge of stakeholders in consultation process such as interviews, workshops and focus groups, were developed to support decisions on environmental investments and problems
(Constanza and Ruth,1998).

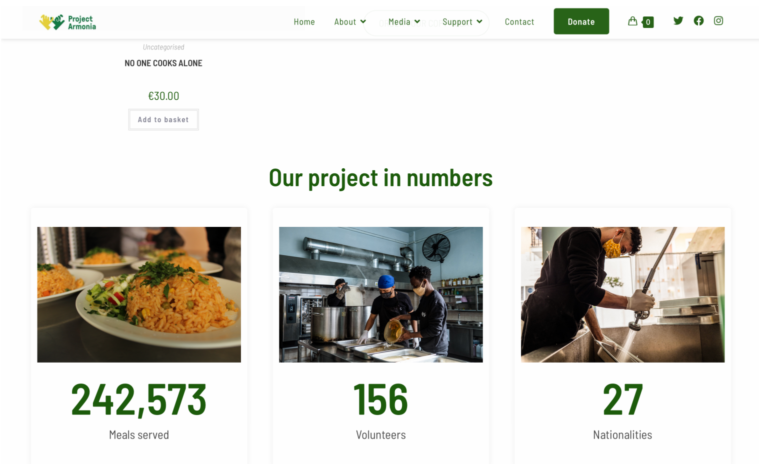
The decision-makers had chance to apply these models in practice and to choose different parameters according to their understanding of the problem
(Weston and Ruth,1997).

As the participants were providing feedback during all stages of model development, the models results were much easier to communicate and implement. Also participants had a much more sophisticated understanding of underlying assumptions, uncertainties and strength of the model and could use it effectively as a management tool
(Costanza and Greer,1995).

Currently, some decision models for multi-hazard and multi-risk assessment are being developed with the aim to provide stakeholders with a set of scenarios or alternatives.These models display different risks with respect to their probability and frequency, as well as to their possible out comes.The decision making models, such as a Multi-Risk Land Use Management Support System developed inframes of the ARMONIA project (T6,2007)



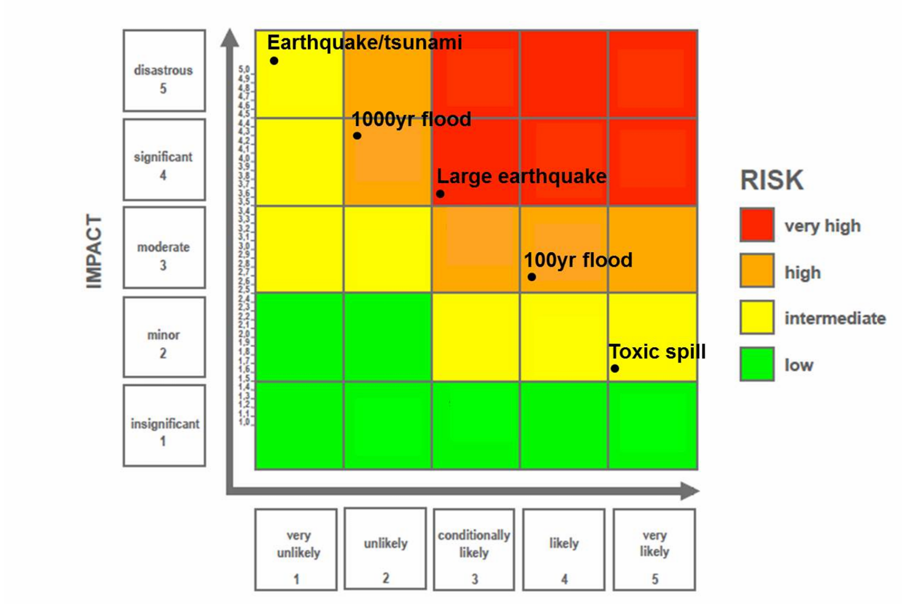
STELLA diagram of the unit model used for the CELSS landscape model. One example of a process-based spatial simulation model is the Everglades Landscape Model (ELM), discussed in section 3. Another example is the Coastal Ecological Landscape Spatial Simulation (CELSS) model, which consists of 2,479 interconnected cells, each representing 1 km 2 , constructed for the Atchafalaya/Terrebonne marsh/estuarine complex in south Louisiana (Sklar et al., 1985; Costanza et al., 1990). Each 1 km 2 cell in the CELSS model contains a dynamic, nonlinear ecosystem simulation model with seven state variables, similar to the one shown in The model is generic in structure and can represent one of six habitat types by assigning unique parameter settings. Each cell is potentially connected to each adjacent cell by the exchange of water and materials. This model is several years old and is much simpler than many models in use today.

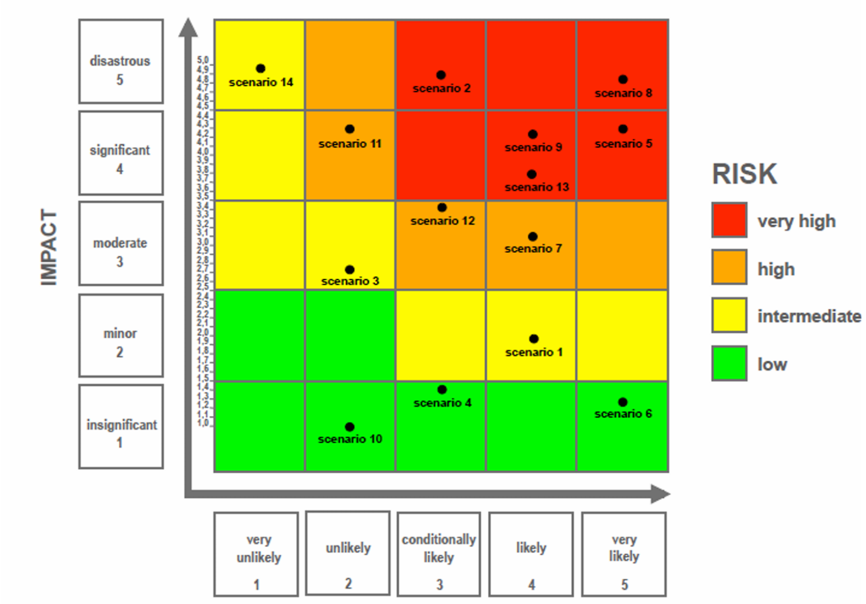


and the scenario-based approach for risk assessment used by the German Federal Office of Civil Protection and Disaster Assistance (BBK,2010) integrate multi-risk concept by visualizing risks and using the risk matrix, which combines likelihood and impact.

The development of such risk matrices was proposed by the risk assessment and mapping guide lines for disaster management developed by the European Commission in 2010 an discurrent practice in several European countries.

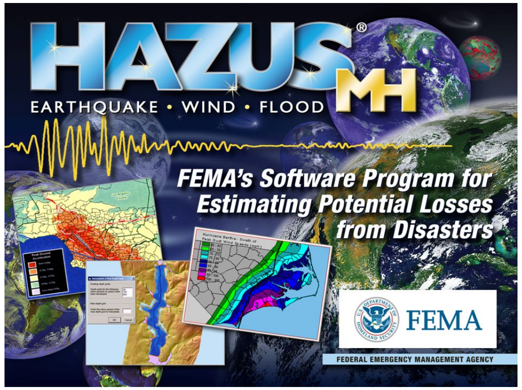
With in the risk matrix, multi-risk events could be represented as additional scenarios (figure1) and thus integrate this information in to the knowledge base for decision making processes. The objectives of these tools are to provide assessment of exposure and vulnerability, to support regarding land use issues and location of strategic facilities, to provide options for mitigating risks through a system of Multiple Criteria Evaluations.





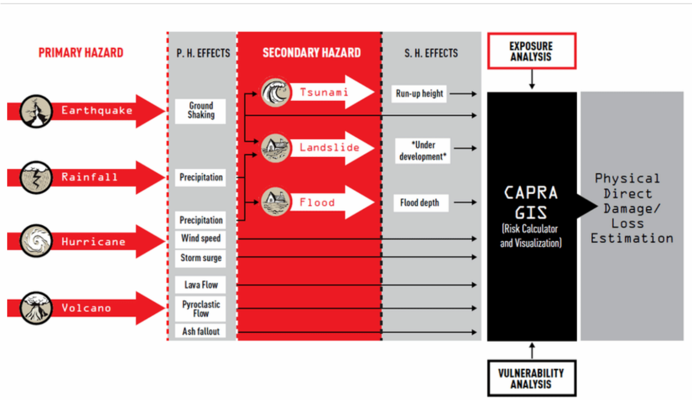
In addition, three principal software tools have been developed to date to provide multiple single risk assessments of a given territory.

HAZUS for the USA (hurricanes, earthquakes and floods).

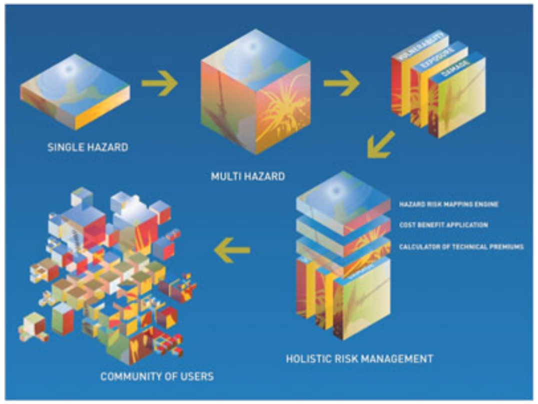


RiskScape for New Zealand (volcanic ash falls,floods,tsunamis,landslides,storms and earthquakes; Schmidt et al.,2011)

CAPRA 2 in CentralAmerica (hurricanes, heavyrainfall, landslides, floods, earthquakes, tsunamis and volcanic hazards; CAPRA Probabilistic Risk Assessment Initiative, 2011).



CAPRA platform framework



Variants of these softwares have been used in other parts of the world (e.g., HAZTURK and HAZTAIWAN, CAPRA in Asia, Risk Scape in South East Asia).

Even though the developers of these tools propose an interactive process with stakeholders, currently as cientific review or evaluation of the results from the use of these softwares and feedback from stakeholders is not available.

More importantly, these softwares do **not include conjoint or cascading disasters**, which is the strict definition of multi-risk.

To our knowledge, even though some of these models have been tested by operational and practicing stakeholders, there is limited evidence of stakeholder feedback.

HAZUS is largely used by stakeholders, mainly government planners and emergency managers, to determine losses and the most beneficial approaches for their mitigation. It is also used by communities for the evaluation of economic loss scenarios with respect to certain hazards and to increase public awareness

(FEMA,2013).

The aim of RiskScape is to be an "easy to use multi-hazard impact and risk assessment tool " and to inform decision-making, including land-use planning, emergency management, assets management and insurance. This tool for esees interactive cooperation with users, and has put in place a development blog on-line where users can exchange their experience with the software and suggest improvements

(Reese et al., 2007).

Thee vidence of participation of stakeholders in the tool development and integration of their feedback is almost absent. One decision-making model developed by ARMONIA defines weights based on the judgments from stakeholders on different vulnerabilities with in the area of their interest. **However,there is no scientific analys is of feedback from experts from civil protection in terms of usability and applicability.**

This deficiency is there fore one of the motivations for our research, where we have collected feedback of stakeholders through the methodology of stakeholders´consultation via such means as questionnaires, decision-making experiments and workshops.

Methodology

Decision support tools, which were applied to collect feedback from stakeholders

Social science scholars argue that because production of scientific tools is a social process, it is essential to involve relevant stakeholders who will be using the tools in to the process through collection and integration of their feedback (Tesh, 1990).

We collected feedback from stakeholders regarding two decision support models. Both models were developed in frames of the MATRIX project.

The first model "Generic multi-risk framework" was developed **by the Swiss Federal Institute of Technology in Zurich (ETH Zurich).** It quantifies multi-risk in a controlled environment to show the benefits of such an approach for decision-making
(Mignan,2013; Mignanetal., submitted).

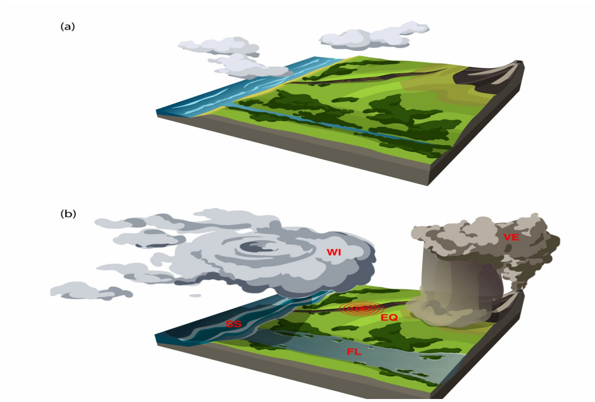
The second model was developed **by B.Khazai at the Karlsruhe Institute of Technology (KIT).** It communicates multi-hazard and multi-risk results to stakeholders, by using concepts of risk ranking and **the risk matrix metric**
(Wenzel,2012).

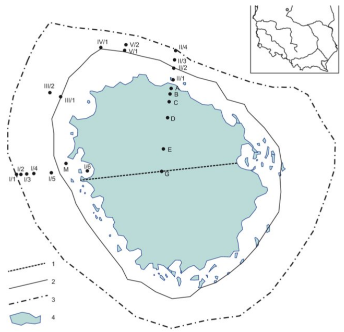
ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

KIT
Karlsruher Institut für Technologie

We describe briefly these models below

Tool#1: Generic multi-risk frame work Mignan et al. (submitted) proposed a generic multi-risk frame work based on the sequential Monte Carlo method to allow for a straight forward and flexible implementation of conjoint and cascading events. The model considers hazard interactions, which are analogue to the ones observed in recent catastrophes, such as the 2005 hurricane Katrina or the 2011 Tohoku earthquake. It also includ estime-dependent exposure and time-dependent vulnerability, **although these aspects were not discussed with stakeholders.** Validation of the framework was based on the testing of generic data and interaction processes. For apesentation of the multi-risk framework to stakeholders, an other set of data and interaction processes was used, based on the **concept of virtual city,** which is illustrated.This concept was also developed with in the **scope of the MATRIX project** (Mignan,2013) but has yet to be fully described (Mignan et al, in preparation).





A virtual city located in a virtual hazardous region gives the base line for the investigation of hazard interactions in a controlled-yet realistic-environment. Perils and interaction processes are defined heuristically (e.g.,earthquakes from simple ground motion prediction equations, floods from water height in a V- basin, storm surge height as a function of wind speed based on the Saffir-Simpson scale, etc.). Risk is also computed from simple considerations (e.g.,log normal distribution as a proxy to various vulnerability curves).

By construction, epistemic uncertainties are high but could be reduced when switching from a virtual scenario to a real one. **Several examples of multi-risk scenarios based on the generic multi-risk frame work and on the virtual city concept were presented at both workshops**. At the second workshop, we conducted the **decision-making experiment** to test the tool again, which was improved after the first workshop according to feedback from stakeholders.

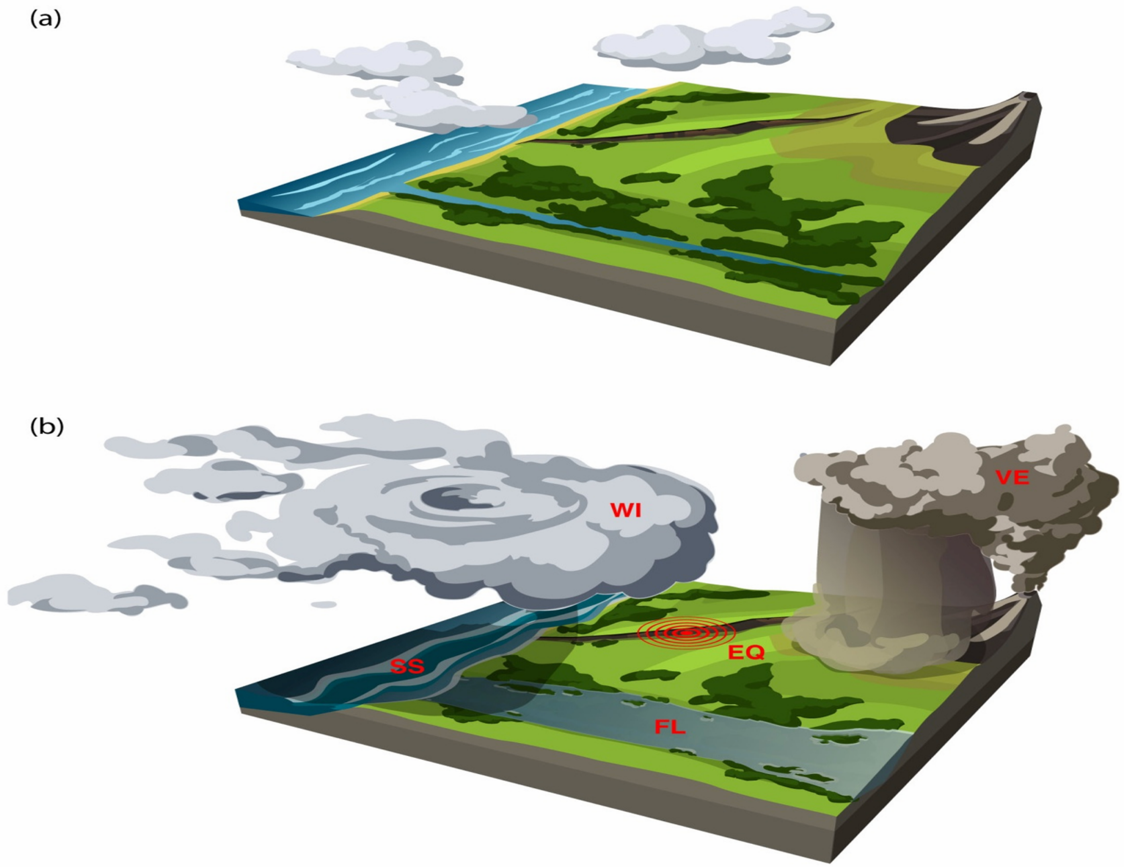


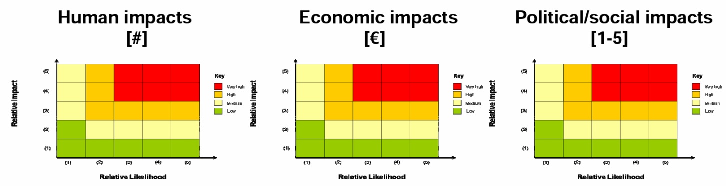
Figure : Concept of virtual city: Artistic representation of a virtual hazardous region. Top: Morphology of the 100 by 100km region. Bottom: perils considered in this version are earthquakes (EQ), volcanic eruptions (VE), fluvial floods (FL) , winds (WI) and sea submersions (SS). The virtual city can be located anywhere in that region.

Source : Mignan (2013).

Tool#2:

Risk matrix decision-support tool. The BBK (2010) risk matrix framework was implemented in to decision - support software by B.Khazai at the Karlsruhe Institute of Technology based on the principles of Multi-Criteria Decision Analysis (MCDA).

The tool was tested with a group of stakeholders for the prioritization of risk scenarios in a delineated region based on user in put. The goal was to test the different interactive features and visualization formats in the tool for communicating and transferring the information contained for the different risk scenarios in the risk matrix to the various stakeholders involved. The risk matrix relates the two dimensions of likelihood (in terms of probabilities of occurrence) and impact (in terms of severity of impact) in a graphical representation of different risks (along multiple impact dimensions) in a comparative way and can be used as a simple approach for setting priorities



Risk matrices can be used in all stages of risk assessment (see below).

Comparison of risk assessment techniques, ISO 31010.
Environmental impacts should wherever possible be quantified in economic terms, but may also be included in non-quantified terms under political/social impacts.
See: Annex to: Non-paper by France, Germany, the Netherlands, Portugal, Slovenia, Spain, and the United Kingdom on *National Risk Assessment.*
See also: Comparison of risk assessment techniques, ISO 31010.

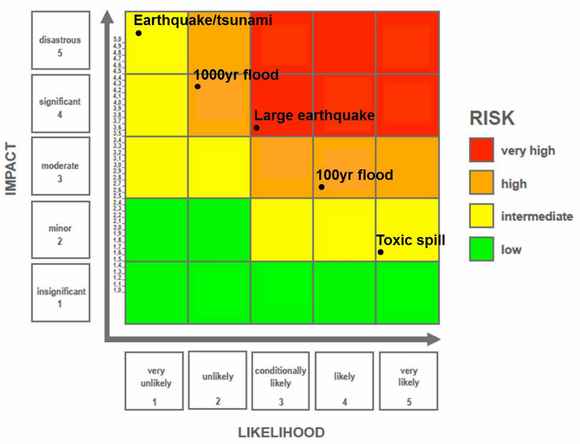


Figure: Risk matrix. Source: BBK, 2010

Accordingly, the risk matrix presents a visual two-dimensional display of the “ranking”of risk scenarios interms of a frequency and impact scale that is relevant to the region of interest,and will help in interpreting historical experience and translating expert opinion in a consistent manner. In this way, the decision-support tool allows the stakeholders to display the total risk index ranking of different risk scenarios (e.g.,anex tremely rare off shore earthquake which can trigger a tsunami, or a release of toxic material with severe impacts on the local environment, etc.) affecting a region in terms of expected losses that are quantitatively derived in different sectors (human, environment, economy, infrastructure, intangibles) for each scenario. The decision support tool allows users to construct a composite impact score for each hazard scenario,by thema thematical aggregation of a set of individual impact indicators that measure multi-dimensional concepts but usually do not have common units of measurement
(Nardo et al.2005).

9. Annex 3: List of Risk Identification Methods

Table 2: Outline of risk assessment tools (ISO 31010, Annex A, p. 23-27)

Risk assessment techniques	Description	Resources and capabilities	Nature and degree of uncertainty	Complexity	Quanti-tative output?
Check-lists	Listing of typical uncertainties	low	low	low	no
Preliminary hazard analysis	Hazards and hazardous situations and events identification	low	high	medium	no
Structured interview and brainstorming	Collection and evaluation of ideas	low	low	low	no
Delphi technique	Combination of different expert opinions on identification, probability and consequence estimation and risk evaluation (+ voting by experts)	medium	medium	medium	no
SWIFT Structured "what-if"	Risk identification by a team (workshop)	medium	medium	any	no
Human reliability analysis (HRA)	Human impact on system performance (evaluation of human error influences)	medium	medium	medium	yes
Root cause analysis (single loss analysis)	Analysis of a single loss and its contributory causes as well as identification of future improvements of the system or process	medium	low	medium	no
Scenario analysis	Qualitative or quantitative identification of possible future scenarios based on present or different risks	medium	high	medium	no
Toxicological risk assessment	Identification and analysis of hazards and exposure. Combination of the level of exposure and the nature of harm to measure probability of the harm occurrence	high	high	medium	yes
Business impact analysis	Analysis of the effect of key disruption risks on an organization's operation and the way to manage them (identification and quantification of capabilities)	medium	medium	medium	no
Fault tree analysis	A graphical determination of all the ways an undesired event could occur (a logical tree diagram) and consideration of reducing/eliminating potential causes	high	high	medium	yes
Event tree analysis	Inductive reasoning for the translation of probabilities of initiating events to possible outcomes	medium	medium	medium	yes
Cause/ consequence analysis	A combination of fault and event tree analysis to include time delays (causes and consequences are considered)	high	medium	high	yes
Cause-and-effect analysis	Identification of contributory factors of an effect through brainstorming (tree structure or fishbone diagram)	low	low	medium	no
FMEA (FMECA)	Failure Mode and Effect Analysis (+ criticality analysis)	medium	medium	medium	yes
Reliability centred maintenance	Identification of policies to be implemented to manage failures in a more efficient and effective manner	medium	medium	medium	yes
Sneak analysis (sneak circuit analysis)	Identification of design errors	medium	medium	medium	no
HAZOP Hazard and operability studies	Definition and assessment of possible deviations from the expected or intended performance	medium	high	high	no
HACCP Hazard analysis and critical control points	Measurement and monitoring of specific characteristics required to be within defined limits	medium	medium	medium	no
LOPA (Layers of protection analysis)	Evaluation of controls and their effectiveness (barrier analysis)	medium	medium	medium	yes
Bow tie analysis	Description and analysis of risk pathways from hazards to outcomes and review of controls	medium	high	medium	yes
Markov analysis	Analysis of repairable complex systems	high	low	high	yes
Monte Carlo analysis	Establishment of the aggregate variation in a system resulting from variations in the system for a number of inputs (triangular or beta distributions)	high	low	high	yes
Bayesian analysis	Assessment of the probability of a result by utilizing prior distribution data	high	low	high	yes

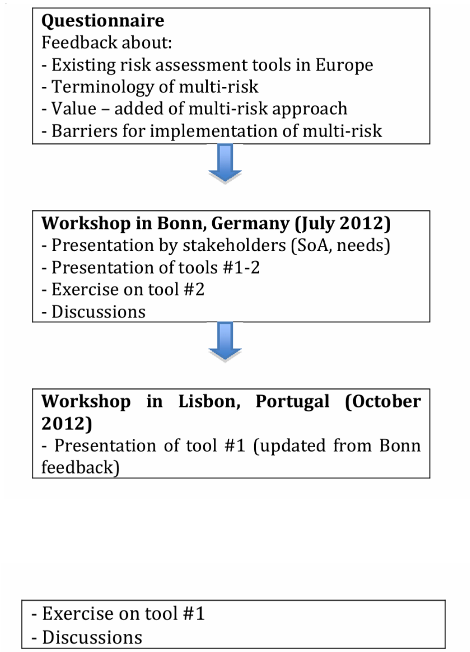
In this way the tool allows the user to input impact from different hazard scenarios in terms of the following dimensions and respective indicators: people (expected casualties, homeless, affected persons), economy (expected financial losses, capital stock, business disruptions), environment (threat to ecosystem, ground water, agricultural areas stability and sustainability), infrastructure (interruption in freshwater, gas, energy, telecommunications, transportation systems) and intangibles (public security, political implications, psychological implications and loss to cultural values).

Through a participatory approach, the stake holders assign the relative importance (weights) to the losses for the different sectors for each of the scenarios likely to occurin the region. While this approach may invite stake holders to draw simplistic conclusions, it can provide a big picture by accounting for different dimensions of impact, including dimensions that are difficult to measure and are often ignored. **In this way the tool is able to summarize a complex multi-dimensional view of scenarios and allows a more rounded assessment of impacts.**

Further more, not all the impact measures and dimensions are of equal importance, and the decision support tool allows the users to dynamically change the weights as signed to each indicator based on its perceived importance and immediately observe changes in the composite impact score of the different risk scenarios.

Using the interactive features and various visualization tools in the decision support software, such as sensitivity graphs, stacked bars, scatter plots, and pair-wise comparisons between scenarios, the aim is to facilitate communication among the stakeholders to determine which of the multiple risk scenarios should be prioritized by considering many variables at once and better communicate their choice too thers.

Methods of stake holders interactions Our approach to collect feedback from stakeholders includes several methods, among them the distribution of questionnaires and the organization of workshops with presentation of tools, exercises and discussions (figure).



Importantly, we collected feedback from those stakeholders who participated at the workshops mentioned above and combined this information with that obtained from questionnaire distributed prior to the workshops.

Two workshop were organized, the first one was held in Bonn, Germany, on the 6 th and 7th of July 2012, under the aus pices of the MATRIX project. The second workshop took place on the 17th to 19th of October 2012 in Lisbon, Portugal, **sponsored by the Italian Civil Protection** ("Multi-hazard risk assessment in urban environment", 12th PPRD South" prevention and preparedness" workshop for staff-level officials).

The workshop in Bonn was the main source of data on stakeholder's perceptions while the one in Lisbon provided us with a secondary source of data dealing with perceptions of the tools developed after feedback from stakeholders in Bonn.

The list of stakeholders present during the two workshops is given in Table1 and Figure 6.

Bonn Workshop	Lisbon workshop
1. Austria, Federal Ministry of Agriculture, Forestry, Environment and Water Management 2. Czech Republic, National Committee for Natural Disaster Reduction 3. Croatia, National Protection and Rescue Directorate 4. France, Ministère de l'Ecologie, de l'Energie, du Développement durable et de la Mer 5. Germany, Federal Office of Civil Protection and Disaster Assistance 6. Italy, Civil Protection Department 7. Norway, Directorate for Civil Protection and Emergency Planning 8. Sweden, Center for Climate and Safety 9. Switzerland, United Nations International Strategy for Disaster Reduction	10. Albania, Civil Emergencies 11. Algeria, General Directorate of Civil Protection 12. Bosnia and Herzegovina, Ministry of Security 13. Egypt, General Administration of Civil Protection 14. Israel, Ministry of Home Front Defence 6. Italy, Civil Protection Department 15. Jordan, Rescue and Support Directorate 16. Lebanon, Civil Defence 17. Mauritania, Mayor 18. Montenegro, Department for Civil Protection 19. Morocco, General Directorate of Civil Protection 20. Portugal, National Authority for Civil Protection 9. Switzerland, United Nations Office for Disaster Risk Reduction 21. Tunisia, Civil Protection
Questionnaire only	
22. Poland, Institute of Meteorology and Water Management, National Research Institute (IMGW)	

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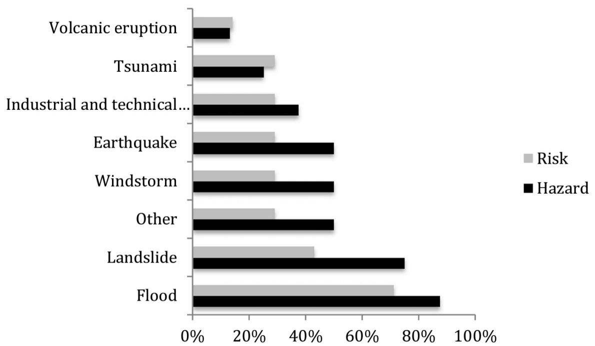


Figure 6: Distribution of the application of different types of hazard and risk assessment in the eight European countries represented in the questionnaire distributed prior to the Bonn MATRIX workshop.

Additionally, other stakeholders answered to a questionnaire sent before the Bonn meeting but without participating to the workshop.

During our stakeholder consultations, we worked together with representatives from National Platforms for Disaster Risk Reduction, which are most commonly parts of the national Civil Protection. Further more, the United Nations Office for Disaster Risk Reduction (UN-ISDR) and the Federal Ministry of Agriculture, Forestry, Environment and Water Management, Austrian Service for Torrent and Avalanche Control, have been involved.

The stakeholders agreed to cooperate and to provide their feedback on tools after an official request from GFZ (the MATRIX project coordinator) and the German Committee for Disaster Risk Reduction (DKKV).

National Platforms are governmental organizations, for example, at the level of the Ministry of Interior-Civil Protection Department or a reacting as non- governmental organizations like the German Committee for Disaster Reduction (DKKV).

They are multi-stakeholder committees comprising experts and members from different sectors, enabling them to act as centers of expertise in the field of disaster risk reduction (DRR).

National Platforms are advocating for DRR at all governmental and social levels and are generally responsible for coordinating DRR activities, which require a coordinated and participatory process. According to the definition from the UN-ISDR, a National Platform for Disater Risk Reduction (DRR)" should be the coordination mechanism for mainstreaming DRR in to development policies, planning and programs in line with the implementation of the Hyogo Frame work for Action (HFA). It should aim to contribute to thee stablishment and the development of acomprehensive national DRR system, as appropriate for each country".

The United Nations Office for Disaster Risk Reduction is the secretariat of the UN-ISDR, and is the successor arrangement of the secretariat of the International Decade for Natural Disaster Reduction (IDNDR). It was established in 1999 in order to ensure the implementation of the UN-ISDR and the Hyogo Framework for Action (HFA,2005), which was adopted during the World Conference on Disaster Reduction in Kobein 2005.

IDNDR
1990 – 2000
Building a Culture of Prevention

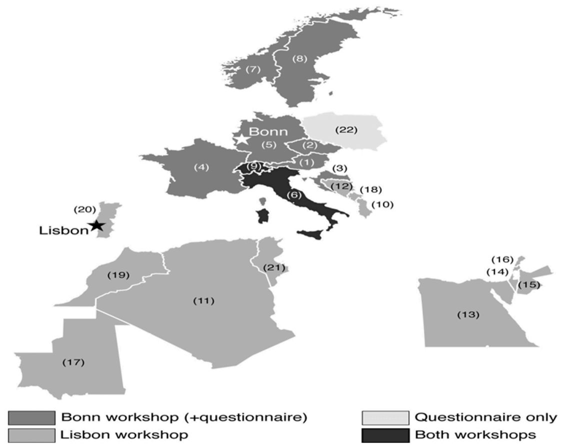
World Conference on Disaster Reduction
18-22 January 2005, Kobe, Hyogo, Japan

Amongst the different activities the secretariat's mandate involves:

(1) Is to"provide support to countries and HFA focal points in the establishment and development of national platforms for DRR and backs top their policy and advocacy activities;
(2) develop improved methods for predictive multi-risk assessments,including on the economics of DRR and socio-economic cost-benefit analysis of risk reduction; and integrate early warning systems in to their national DRR strategies and plans".

The selection of stakeholders forms are presentative sample, given the fact that over 50% of all national platforms in Europe were involved in to our research. The stakeholders, except for Austria,represented the National Platforms.

Someone might argue **that the number of stakeholders involved might be too small** for a large-scale survey.
However, here **we would like to point to the fact that our aim was not to conduct a large-scale survey but to reach targeted groups of stakeholders such as civil protection platforms and UN-ISDR. As we do not apply methodology of large-scale survey but use specialized targeted questionnaire** as well as collect feedback during workshops, we regard our sample of stakeholders as representative as it covers most of the European countries (figure).



With **regards to the Bonn workshop** and the questionnaire, considering that there are about 15 national platforms in Europe, 8 participated in the workshop, as well as UNISDR, and 8 responded to a questionnaire (Austria, Czech Republic, France, Germany, Italy, Norway, Polandand Sweden), which was distributed before the workshop. At the Lisbon workshop, stakeholders from Southern Europe, the Balkans, MiddleEastern and North African countries participated.

UNISDR
The United Nations Office for Disaster Risk Reduction

The Questionnaire

A first questionnaire was developed and distributed to stakeholders before the Bonn workshop to elicit base line perception of the group of civil protection officers in order to compare with perception safter wards. It also served as away to elicit problems perceived by stakeholders in order to discuss them during the first workshop.

The general aim of the questionnaire was to collect feedback from the civil protection community about the current status of multi-risk approaches, such as availability, methods, and barriers, of hazard, risk and multi risk assessments among the involved European countries.

The focus was to understand the value of multi-hazard and multi-risk approaches and tools in real world conditions. This involved questions such as:

- What are the added values of hazard and risk assessments and what are their levels of integration in to decision-making processes?

- What are the requirements for multi-risk assessment methods and tools from the perspective of disaster management ?

The surveys allowed us not only to gain answers to the questions set above, but to also capture the stakeholders' perceptions of the term multi-risk.

We summarized the results of the questionnaire, presented them and discussed out puts with the stakeholders during the workshop in Bonn.

The aim of the developed questions was to capture their understanding of the term" multi-risk", to obtain an overview of the state-of the art of hazard, risk and multi-risk assessment, to receive feedback on the level of integration of hazard and risk assessments in to decision making processes, to assess the usefulness of multi-risk scenarios for disaster management strategies, to receive feedback on requirements for multi-risk methods and tools, to receive feedback on the potential of integrating the multi-risk methodology developed **by MATRIX** in the domain of the National Platform.

Questions were related to :

the availability of comprehensive hazard, risk and multi-risk assessments, description of applied hazard and risk assessment methodologies,use and usefulness of hazard,risk and multi-risk assessments in decision making processes, use of probabilistic and scenario analysis, estimations of uncertainties and socio-economic and engineering models in hazard and risk assessment, requirements formulti-hazard and multi-risk assessment methods and tools, parameters require to be considered, communication of multi-risk to decision making processes, advantages of multi- risk in comparison to single risk assessment, potential of integrating the multi risk methodology developed by MATRIX in the domain of the National Platform and barriers in implementing multi-risk methods.

Bonn workshop:

The following activities were performed during the Bonn workshop : presentation and discussion of the results of the questionnaire, which was submitted to the stakeholder before the workshop, presentations from stakeholders and discussion on hazard and risk assessment approaches in Europe, presentation and discussion of the generic multi-risk framework and the decision support tool.

These activities contributed to a better understanding of the current approaches and to the further development of the tools.

The Bonn workshop provided :

the opportunity to present and discuss current hazard and risk mapping concepts and high light the importance of data and information for multi-hazard and multi-risk assessments as well as the added value of the multi-risk approach. It also provided an opportunity to discuss multi-risk decision support tools in three aspects ; first, to capture the status of different approaches and open problems with regards to multi-risk assessment in Europe, second, to understand the users' requirements with regards to information technology for the generation of scenarios, third, to understand the range of risk components addressed in the current practice, such as losses to people's health and lives, economy, ecological damage, impacts upon infrastructure and critical infrastructure, and intangible losses.

Additional interactions on tool #2

allowed us to identify differences in the perceptions between stakeholders from science and practitioners. **The generic multi-risk frame work (tool#1) and its application in a virtual city were presented by A.Mignan and the risk matrix decision-support tool**

(tool#2) was presented by B.Khazai. No exercise involving tool # 1 was proposed in the Bonn workshop.

An exercise of tool#2 followed in which stakeholder input was needed to identify the weights with which the impact of particular components in the overall picture of impact are specified in a participatory fashion (i.e.,what is the relative importance of the different loss parameters in the risk ranking ?) .

Thus,the primary difficulty in gathering stakeholder input involved creating a value model " that would support stakeholders in assessing problems and expressing their views more explicitly.

Using the decision - support tool in the workshop, the stakeholders ranked and compared risk scenarios to each other relative to one (or several) loss criteria by following the five steps below:

1-Identify all the risk scenarios to be ranked.
2-Identify loss parameters to quantify the risk score of each scenario. .
3-Quantify the loss score (5 categories, from irrelevant to catastrophic) for each of the loss parameters for each scenario.
4- Quantify preferences (weights) for different loss categories and loss parameters.
5- Rank the scenarios by combining information from steps (4) and (5).

Following the ranking of the scenarios, the stakeholders used the visualization tools of the decision-support software tool to conduct interactive sensitivity analyses to detect the most significant factors in the ranking of scenarios, and identify whether or not a criteria differentiates between two scenarios.

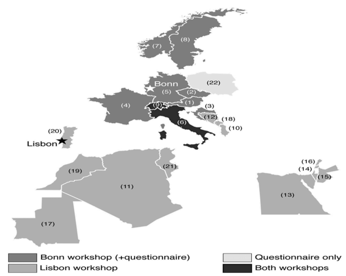
Further more, stakeholders discussed way stocharacterize uncertainties in the loss parameters and set priorities by determining how much greater risk one scenario poses overan other.

Note:
 Worthy,to save on time, **only B.Khazai was directly interfacing with the tool, taking in to account recommendations from the stakeholders and showing the out comes on a large screen (i.e.,interactive tutorial)**

3.2.3.Lisbon workshop

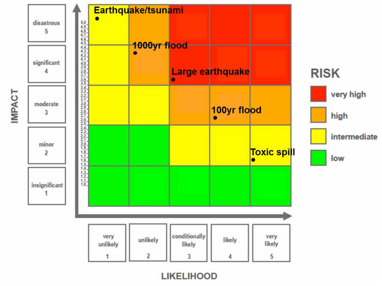
Apresentation of the generic multi-risk framework (tool#1) in Lisbon was followed by a half-day exercis eco-organized with the PPRD South team and others peakers.

The exercise's aim was to provide a better understanding of the role of multi-hazard in over all risk assessment by considering. two sites: Lisbon, Portugal and Istanbul, Turkey.The participants were divided in several groups of about 5 persons with discussions promoted with in and between groups (figure).



The first part of the exercise consisted in investigating the different hazards present in the two cities base don various data, such as hazard maps, provided in the guidelines of the exercise,and to give some score to their severity and frequency, that is with in the concept of the risk matrix-hence here combining the tool#1 core modeling concept with a visualization and ranking of multi-risk similar to tool #2.

This upgrade of tool#1 was based on feedback obtained during the Bonn workshop (see section 4).



The second part of the exercise was to discuss potential triggering effects, based on the virtual city results and past catastrophes known of the participants.

Participants then up dated their risk matrix based on multi-hazard information and presented their new results.

The final objective was to high light the idea that new risks emerge and some others may shift to lower-probability higher-consequences events when multi-hazard is considered in risk management.

While the participants did not use the generic multi-risk framework perse, they could perceive its basic concept via the exercise.

Results