Project acronym: CHANGES
Project full title: **C**hanging **H**ydro-meteorological Risks – as **A**nalyzed by a **N**ew **G**eneration of **E**uropean **S**cientists

Grant agreement no.: 263953

Date of approval of Annex I by Research Executive Agency: 27 August 2010
Type of Instrument: Marie Curie Research Training Network (RTN)

Final Report

Period Number: 2

Due date of deliverable: 30/03/2015

Period covered: from 01/01/2011 to 31/12/2014

Date of preparation: 20/03/2015

Date of submission: 20/03/2015

Start date of project: 01/01/2011

Duration: 4 years

Project coordinator organisation name: ITC

Table of Contents

1. Reflection on the project objectives

The CHANGES network (Changing Hydro-meteorological Risks – as Analyzed by a New Generation of European Scientists) aimed to develop an advanced understanding of how global changes (related to environmental and climate change as well as socio-economical change) will affect the temporal and spatial patterns of hydro-meteorological hazards and associated risks in Europe; how these changes can be assessed, modelled, and incorporated in sustainable risk management strategies, focusing on spatial planning, emergency preparedness and risk communication. The MCITN is inter-disciplinary and inter-sectoral by its nature. Active stakeholders' participation and the dissemination of the project results are important features of the project. High-level training facilities as well as scientific and technological excellence were provided to the next generation of researchers in the field of hazard and risk management. The CHANGES network hopes to contribute to the Topical Action numbers 2 and 3 of the Hyogo Framework for Action of the UN-ISDR, as risk assessment and management, combined with innovation and education are considered essential to confront the impacts of future environmental changes (ISDR 2009). The network consists of 11 full partners and 6 associate partners of which 5 private companies, representing 10 European countries..

Figure 1: Screenshot of the webpage of the CHANGES project (**http://www.changes-itn.eu/**) which contains descriptions of all activities and results obtained in the project.

This Marie Curie Initial Training Network (CHANGES) aimed at providing an innovative, scientific approach for an integrated risk-based management of priority areas in Europe. The objectives of the CHANGES network were:

1. To provide high-level training, teaching and research in the field of hazard and risk management in a changing environmental context to a group of 12 Early Stage Researchers, of which at least 50% are females, which will be hired by the 11 participating partners before month 8 of the project, and 3 Experienced Researchers, which will be hired before month 23 of the project. In relation to the first objective the following points can be mentioned:

   - The initial 12 ESRs were hired in the first year of the project. The vacancies were widely announced and over 800 applications were received from all over the world. The partners selected the 12 ESRs, of which 9 are female, and from the following countries: New Zealand, Germany (2), Belgium, Slovenia, Romania, Netherlands, Italy, Myanmar, Colombia, USA and Switzerland.
   - All ESRs started by 1 January 2012. In the first period they have been very active in developing their research proposals, and in training activities. All 12 ESRs completed their Career Development Plans and Research Proposals, which were presented in project meetings in Enschede (January 2012), Italy (April 2012) and during a Young Researcher Forum, held in July 2012 in Salzburg. During this meeting the ESRs presented their proposal for a larger audience and experts from related EU projects, and received valuable feedback. All research proposals and CDP are available on the CHANGES website, in a section only accessible for the project partners.
   - The ESRs have gained maximum exposure through secondments with other partners and with associated partners. Most of the ESRs had initiated their secondments in the second year of the project, and carried out secondments in different locations. In practice the secondments were mostly not exactly according to the original plans and were not in continuous periods of several months, but rather in a larger number of shorter visits, as this fitted better in the ESR research. Secondment planning with some of the associated partners was problematic due to lack of response by some of the associated partners.
   - In the original DoW it was indicated that 3 ERs would be hired by two partners each for a period of 12 month, of which 6 months will be spend with an associated partner from the private sector. The 3 positions were widely advertised, but we received an unbalanced number of applications, (0 for ER1, 38 from ER2 and 1 for ER3). Unfortunately none of the applicants was eligible in terms of technical background and especially with the required maximum of 5 years research experience. It was therefore decided to hire 6 ERs by 6 partners (as indicated in the DoW) for 12 month each. The hiring process took place in 2013, and we advertised the positions widely through EurAxess, ITC website and other job-sites. We received 54 applications of which we selected 5 ESRs. All ESRs were hired by July 2013 for a period of 18 months.
   - According to the DoW each of the ESRs was expected to have published at least 2 joint scientific publications with other ESRs/ERs or project partners. Most have presented papers in conferences. The consortium as a whole has published many papers in relation to the theme of the project and the research areas.
   - The project has organized a number of network activities, including 6 Professional Skills courses, 5 Technical Skills courses, plus one additional technical course not indicated in the DoW, and 5 Topical Workshop. Also a substantial number of participants from outside of the network have participated in the network events, and also a number of external expert were invited to give presentations in the network meetings.

2. The second objective of the project is to develop an innovative methodological framework combined with modelling tools for probabilistic multi-hazard risk assessment taking into account changes in hazard scenarios and exposed elements at risk and for increasing risk awareness (use of this information in land use planning and emergency preparedness planning). In this sense the network will facilitate the collaboration between several training centres, research centres and consulting companies with experts of different natural processes, different backgrounds, playing different roles in risk management (researchers, technicians-practitioners, consulting companies, administrations, politicians, population representatives), and working in different socio-economic, legal and environmental contexts. In relation with this objective the following points can be mentioned:
   - Several reports have been produced based on the research proposals of the ESRs, which include an extensive literature review:
   - An inventory of approaches and case studies on the analysis of changes in risk from single or multiple hazards (Deliverable D1.1).

- An Assessment of the current vulnerability situation based on historical developments (D2.1).
- An Inventory of software tools for probabilistic risk assessment (D3.1).
- A Distance education course on Multi-hazard Risk assessment was developed in the third year of the project.
- An Internet-based Decision Support System for the use of risk information in risk reduction has been developed.

3. The third objective is to strengthen and expand collaboration between the teams through the organization of a Collaborative Multi-disciplinary Research and Training Programme (CRTP) associating state-of-the-art experimental, methodological and computational advances to ensure Europe's leadership in this area. The research is divided into the following Work Packages:
   - WP-1: Modeling changes in hydro-meteorological multi-hazards (ESR1, ESR2, ESR3)
   - WP-2: Evaluating changes in exposed elements at risk and their vulnerability (ESR4, ESR5)
   - WP-3: Development of a probabilistic risk assessment platform (ESR6, ESR7)
   - WP-4: Adapting risk management strategies to future changes (ESR8,ESR9, ESR10)
   - WP-5: Establishing a Risk Governance framework (ESR11, ESR12)
   - WP-6: Network training and dissemination
   - WP-7: Project management
   - The coordination of the various work packages is shared among seven partners, which are the theme leaders for the various WPs.
   - The management of the network was carried out by a steering committee, consisting of the network coordinator, deputy-coordinator, WP leaders, a representative from the private partners (Geomer), a representative of the ESRs (ESR11, Teresa Sprague) and an external advisor. The steering committee has had 8 meetings in total, and the minutes are available on the web-site to all project partners. In several of the meeting also the members of the external advisory committee (Prof. D. Petley and Dr. S. Lacasse) were present and provided advice.

4. The fourth objective is to reduce the fragmentation of the research on hydro-geomorphic processes by using the complementary expertise of 11 excellent European academic teams in the fields of Geography, Geomorphology, (Engineering-) Geology, Land use planning, Social sciences, Geo-information and Computer Science, combined with 5 leading and innovative private companies, and 1 Civil Defence organisation. This objective was achieved through the organization of network workshops organized by different partners (in total 5 workshops were organized), the promotion of joint conference presentations and papers in international conferences and meetings (e.g. the EGU annual conference, the FloodRisk conference, and the Young Researchers Forum at GIForum in Salzburg). Also an international conference was organized jointly with the EU FP7 Copernicus INCREO project. We also stimulate the secondment of the ESRs and ERs in associated partners from the private sector, however, as these partners are not financially or contractually linked to the project, it is sometimes difficult to involve them in the project.

5. The fifth objective is to build a scientific attitude of young scientists to take notice of societal relevance and practice of risk management, with openness to other disciplines. The CHANGES project focused on a culture exchange of highly specialised young scientists to embrace the value of interdisciplinary work. The researchers in the field of earth sciences working on hazard and risk modelling, learn the importance of other disciplines, such as social sciences and planning, as an important component in solving the societal problem of increased risk due to future environmental changes. This is achieved by frequent interaction between the 17 ESRs. As evidenced by the list of ESR meetings, there are frequent meeting between the researchers, either during a specially organized project meeting, or self organized by the ESRs. The ESRs have also made stakeholder workshops in the four test sites (France, Italy, Romania and Poland). They also support each other with getting the base data for the four test sites. The data collection for the eastern European testsites in Poland and Romania has turned out to be more complicated than initially planned. Contacts were established with other projects (e.g. EU FP7 Safeland, MOVE, Eura-Net ChanginRisk, DORIS, InCreo, EMAP) and representatives of these projects have participated in some of the project meetings.

The Collaborative Multi-disciplinary Research and Training Programme (CRTP) contains 5 scientific Work Packages (See Figure 2), in which the 12 ESRs are working on specific components.

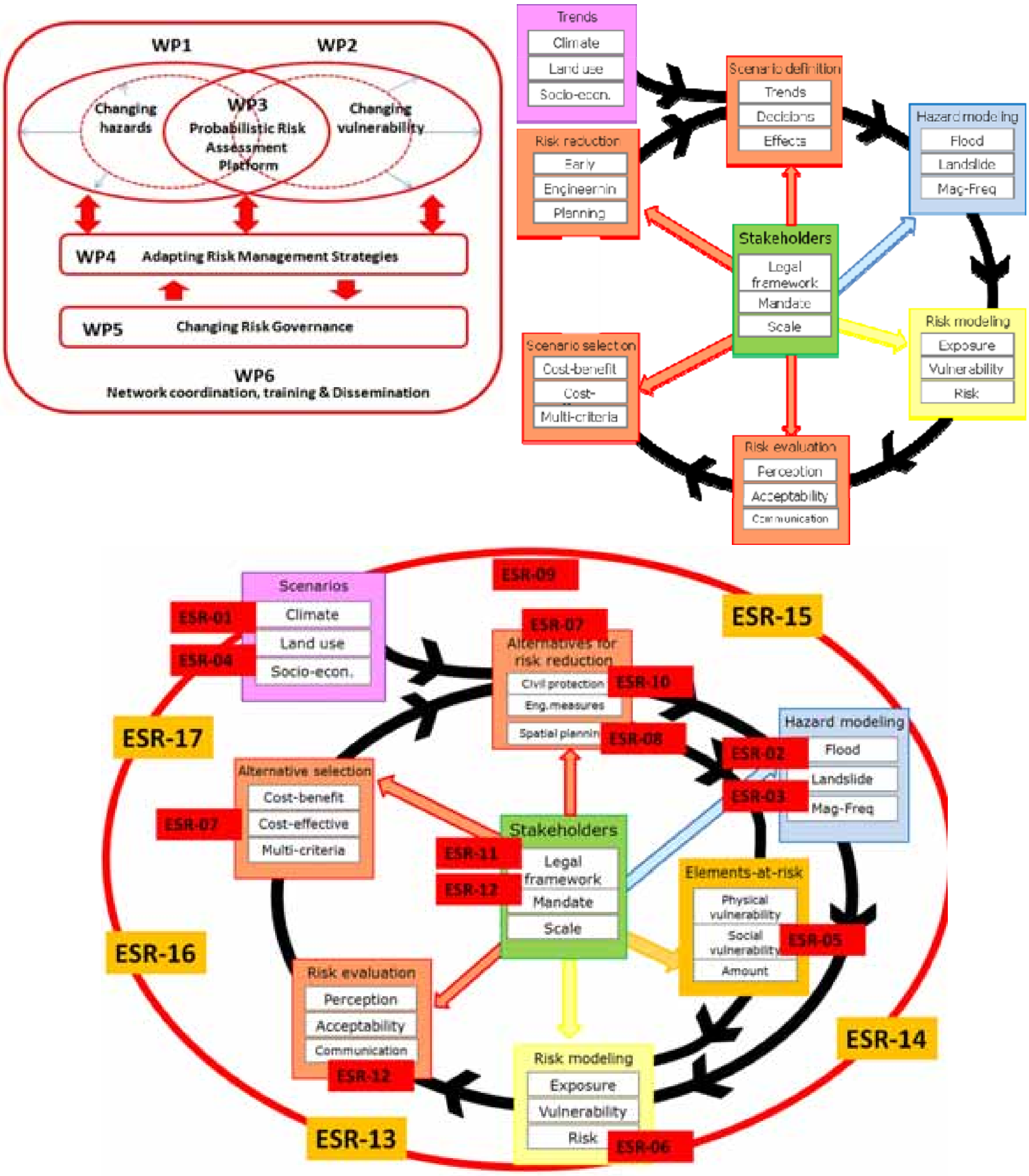


Figure 2: Left: Work Package structure of the CHANGES project. Right: conceptual framework of the CHANGES project indicating the various components that form part of the overall methodology for analyzing the effect of changes in hydro-meteorogical risk and associated risk reduction measures. Below: the subdivision of ESRs over the various components. The ESRs indicated in red are the 36 month ESR focusing on developing the research components, while the five ESRs indicated in orange developed the final web-based system.

Development of an internet-based platform

Within the framework of the EU FP7 Marie Curie Project CHANGES (www.changes-itn.eu) and the EU FP7 Copernicus project INCREO (http://www.increo-fp7.eu) a spatial decision support system was developed with the aim to analyse the effect of risk reduction planning alternatives on reducing the risk now and in the future, and support decision makers in selecting the best alternatives. The SDSS is able to analyse the effect of risk reduction planning alternatives on reducing the risk now and in the future, and support decision makers in selecting the best alternatives. **Error! Reference source not found.** shows a concept of the SDSS. Central to the SDSS are the stakeholders. The envisaged users of the system are organizations involved in planning of risk reduction measures, and that have staff capable of visualizing and analyzing spatial data at a municipal scale. The SDSS should be able to function in different countries with different legal frameworks and with organizations with different mandates. These could be subdivided into:

a) Civil protection organization with the mandate to design disaster response plans.
b) Expert organizations with the mandate to design structural risk reduction measures (e.g. dams, dikes, check-dams etc).
c) Planning organizations with the mandate to make land development plans.

Another set of users are those working in organizations that are responsible for providing hazard maps related to flooding and landslides. These are different from the end –users, and they should provide relevant information on request of the end-users. These users are information –providers and are not using the system to make new hazard maps.

A third set of users are those that provide data on elements-at-risk. They are related to organizations related to cadastral data, transportation organizations, etc.

Risk modeling is the central module of the SDSS. It could be carried out by the main stakeholders or by special organizations that deal with risk assessments. In the SDSS design both options are possible.

The SDSS can be used in different ways:

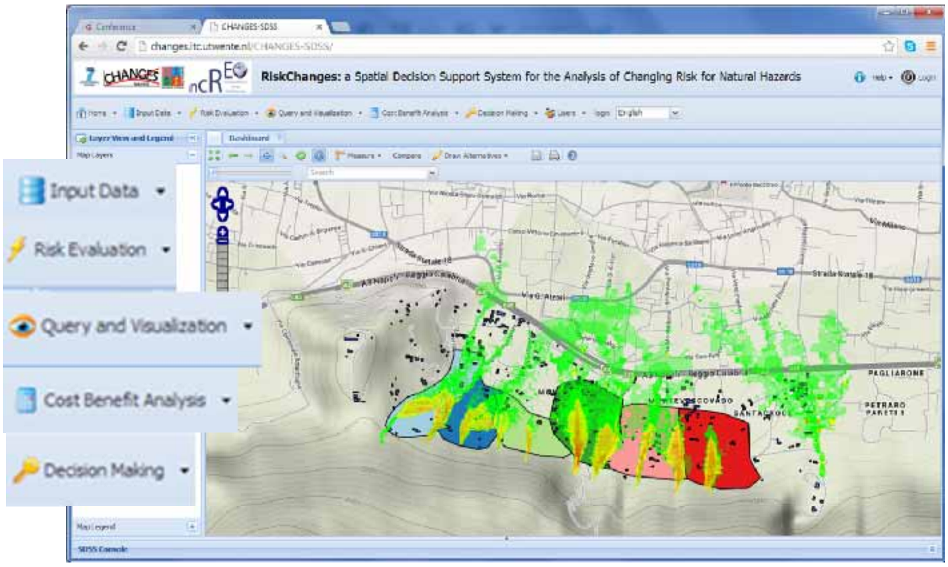
a) **Analyzing the current level of risk**. In this workflow the stakeholders are interested to know the current level of risk in their municipality. They request expert organizations to provide them with hazard maps, asset maps, and vulnerability information, and use this information in risk modeling. They use the results in order to carry out a risk evaluation.
b) **Analyzing the best alternatives for risk reduction**. In this workflow the stakeholders want to analyze the best risk reduction alternative, or combination of alternatives. They define the alternatives, and request the expert organizations to provide them with updated hazard maps, assets information and vulnerability information reflecting the consequences of these scenarios. Note that we do not envisage in the SDSS that these maps are made inside of the system, as they require specialized software and expert knowledge. Once these hazard and asset maps are available for the scenarios, the new risk level is analyzed, and compared with the existing risk level to estimate the level of risk reduction. This is then evaluated against the costs (both in terms of finances as well as in terms of other constraints) and the best risk reduction scenario is selected. The planning of risk reduction measures (alternatives) involves:
    - **Disaster response planning**: focusing on analyzing the effect of certain hazard scenarios in terms of number of people, buildings and infrastructure affected. It can also be used as a basis for the design of early warning systems.
    - **Planning of risk reduction measures**, which can be engineering measures (such as dikes, check-dams, sediment catchment basins), but also non-structural measures such as relocation planning, strengthening/protection of existing buildings etc.
    - **Spatial planning**, focusing on where and what types of activities are planned and preventing that future development areas are exposed to natural hazards.
c) **The evaluation of the consequences of scenarios to the risk levels**. The scenarios are related to possible changes related to climate, land use change or population change due to global and regional changes, and which are not under the control of the local planning organizations. The systems will evaluated how these trends have an effect on the hazard and assets (again here the updated maps should be provided by expert organizations) and how these would translate into different risk levels.
d) **The evaluation how different risk reduction alternatives will lead to risk reduction under different future scenarios** (trends of climate change, land use change and population change). This is the most complicated workflow in the SDSS, as it requires to calculate the present risk level, the effect of different risk reduction alternatives, and the overprinting of these on the scenarios. For each of these combinations of alternatives & scenarios new hazard, assets and risk maps need to be made.

The SDSS is composed of the following integrated modules:

- **Data input module.** This module allows the users to create their own study area, upload maps representing the current situation of hazard maps and elements-at-risk. The users can create projects that deal with the generation of possible risk reduction planning alternatives and/or future scenarios in terms of climate change, land use change and population change, and the time periods for which these scenarios will be made. The module defines the input maps for the effect of the specific combinations of alternatives, scenarios and future years in terms of the hazard and assets maps. It also allows users to make the link between the elements-at-risk types and the vulnerability curves that are stored in a vulnerability database. Users can also enter or upload their own vulnerability curves.

- **Risk modeling module**. This module allows to carry out spatial risk analysis, with different degrees of complexity, ranging from simple exposure (overlay of hazard and assets maps) to quantitative analysis (using different hazard types, temporal scenarios and vulnerability curves) resulting into risk curves. The module first calculates the losses for specific combinations of hazards (in terms of hazard type and return period) and elements-at-risk. Users can then decide the type of risk assessment they would like to carry out (e.g. for specific hazard, specific elements-at-risk, economic risk or population risk and for which alternatives and scenarios). The system does not include a module to calculate hazard maps, as there are many different methods which are applied depending on the scale, available data and objectives of the study. Therefore, hazard maps are considered as input data for the risk module.
- **Cost-benefit analysis module.** This module uses the risk reduction alternatives defined under a project in the data input module and the risk results for the current situation and after implementing these alternatives. The risk is calculated in the risk assessment module. The user can define the costs for the alternatives, and carry out cost-benefit analysis for the alternatives, which also takes into account how the costs and benefits might change in future years depending on the possible future scenarios.
- **Multi-Criteria Decision module**. This module supports the users in determining the most optimal risk reduction alternative, based on the results of the risk assessment and the cost-benefit analysis, and on user defined criteria. These indicators are standardized, weighted and the optimal alternative under different possible future scenarios is determined.
- **Communication and visualization module.** Visualization is a very important module within the SDSS. The SDSS can use many scenarios and alternatives, and the organization of the data should be very well designed. The visualization is not only in the form of maps, but also in other forms (risk curves, tables, graphs). Also the methods for visualizing changes of maps through time should be well designed.

The system is online, and can be accessed through the following URL:
http://changes.itc.utwente.nl/CHANGES-SDSS/
The start page of the system is shown in the Figure below.



In the following sections the achievements within the five scientific work packages and the 17 ERS will be presented. The presentation of the results of the ESRs will be done in the same manner. Each ESR was asked to write a report that focused on three question:

- What are the main achievements of your research?
- What were the main challenges in your research?
- How did you benefit from the Marie Curie Initial Training Network?

2. Main results in relation to general objectives of WP1

Objective:
The main objective of WP1 was to analyze the changes in hydro-meteorological hazards that are expected as a result of environmental changes. These changes are related to climate change and to expected changes in land use/land cover and ecosystems.
The tasks were mainly devoted to develop both regional and local scale probabilistic hazard assessments for floods, landslides and debris flows. Historic information on the hazards and on their effects have been computed (with different levels of details) for three regions (Barcelonnette / Ubaye Valley in France; Buzau County in Romania; and Fella River in Italy). Information on the triggers (mainly rain) and conditioning factors (slope, lithology, local tectonics, landcover) of the observed events have also been collected at several spatial and temporal scales.
These data were used for further analysis of the relationships among triggers and slope/catchment responses in order to simulate the future trends in the occurrence of the hazards according to forecasted climate/landcover changes. The ultimate goal is, through modeling, to propose possible hazard scenarios (including possibly cascading effects) with associated quantitative probabilities of occurrence and indications of the magnitude and extent of the hazards.

Main achievements:

2.1 Task1-1: Inventory of approaches and case studies on the analysis of changes in risk from single or multiple hazards.

This task was carried out by CNRS, ITC and PLUS, and resulted in deliverable: D1.1. Report on the inventory of approaches and case studies on the analysis of changes in risk from single or multiple hazards. This deliverable was composed of the three literature reviews related to the ESRs within this WP.

2.2 Task1-2: Translation of the results of climate change models to expected changes in triggering conditions of hydro-meteorological hazards.

ESR-01 Thea Turkington, University of Twente, the Netherlands

2.2.1 Introduction

The overall purpose of the research was to create a methodological framework for identifying the hydro-meteorological triggering factors for different natural hazards, and then quantifying changes in these triggers as a result of climate change projections. Global and regional climate models project changes for many different meteorological variables for Europe in the coming century. Some of these variables directly impact the hydrological systems and could cause changes in flood and landslide hazards. However, GCMs and RCMs are at a scale that is too coarse for most hydrological models that investigate these processes. Therefore the challenge was to extract relevant information from the larger-scale models for the hydro-meteorological hazards. Furthermore, the results obtained should be useable for flood and landslide hazard assessment that incorporate climate change.
There were four main research phases proposed: observed meteorological changes, identifying meteorological conditions important for triggering hydro-meteorological hazards, downscaling climate projections for these conditions, and finally presenting result and uncertainty. During the first three years of the PhD (the overlap with CHANGES), only the first three research phases were dealt with. The main achievements and challenges from each of the sections are outlined below. The final section is a reflection of the personal benefits from the CHANGES Marie Curie Initial Training Network.

2.2.2 Objectives, outcomes and challenges

- Observed meteorological changes

Long time-series often contain shifts in the data from non-climatic factors. These include changes in the recording techniques and changes in site characteristics. Furthermore, understanding past climate trends can provide information about how an area may respond to changes in climate in the future.

Climate data from two CHANGES study areas were examined for inhomogeneities (non-climatic shifts), and trends. These were Ubaye Valley, France, and Fella River Italy. It was not possible to include the Poland study area, due to prohibitive data costs. The data from Romania was obtained later in the project, and was assessed by an MSc student. A third study area (Salzach, Austria) was also included, but is not included in this report. Results for the two assessed study areas showed that the data was generally homogenous from the 1950s onward, with a few possible shifts 1980s/early 1990s due to changing of instrument type, and therefore can be tested for trends in the data. Using the RClimDex software (Zhang and Yang 2004) different climate extreme indices were tested for trends (Table 1). A full list of the different indices can be found at: **http://eca.knmi.nl/indicesextremes/indicesdictionary.php#8**.

- Meteorological conditions important for triggering hydro-meteorological hazards

It was expected that in this part of the research, key atmospheric situations for hydro-meteorological would be identified and analyzed, as well as finding a correlation between meteorological observations and flood and landslide occurrence. During this process, a new methodology was developed to utilize regional atmospheric conditions for flash floods and debris flows (Turkington et al. 2014). The methodology was applied to the Ubaye Valley for both flash floods and debris flows (Figure 1). High discharge in the Ubaye River was also considered, but the improvements were only minor as temperature and precipitation records can be used already as good proxies for high discharge events. In the end, the methodology was expected to be beneficial for areas where there was limited rainfall data, or the rainfall triggering events were not adequately captured. While it was expected that both floods and different types of landslides would be assessed, the focus was primarily on flash floods and debris flows. For flooding in the main river channel, temperature and precipitation measurements were already adequate, or better improvements could be obtained through modelling (undertaken by ESR-02). Due to time constraints, landslides were not considered at this stage of the research. Rainfall thresholds were also considered for the Fella River study area (not included).

Table 1 Trends in the extreme indices per decade, for one station in Ubaye Valley and four stations in Fella River. Dark grey box indicates no significant trend (at 10% level), light grey indicates trend with pvalue between 0.1 and 0.05, and white boxes indicate trends with pvalues less than 0.05. Tn = minimum temperature Tx = Maximum temperature. 10p = 10th percentile. A star (*) indicates that the trend may be affected by a non-climatic shift in the data.

	Ubaye	Fella River			
	1	1	2	3	4
Summer days (days)	0.44	0.32	0.29		0.88
Ice days (days)	-0.07		-0.20	-0.18	
Frost days (days)			-0.26		-0.95
Growing season length (days)	0.72		0.43	0.3	
Maximum Tmax (°C)			0.03		0.08
Maximum Tmin (°C)			0.05		
Minimum Tmax (°C)	0.04		0.03		0.09
Minimum Tmax (°C)			0.06	0.05	
Cool days < Tx10p (days)	-0.1		-0.11		
Warm days >Tx90p (days)	0.22	0.14	0.13	0.063	0.29
Cool nights < Tn10p (days)			-0.08	-0.09	-0.2
Warm nights > Tn90p (days)		0.11	0.26	0.05	0.41
Warm spell duration indicator (days)	0.42	0.25	0.21	0.15	0.64
Cold spell duration indicator (days)	0.03		-0.05		-0.16
Diurnal temperature range		0.01			
Simple daily intensity index	-0.02				
Number days precipitation > 10mm		-0.14		-0.12*	-0.38*
Number days precipitation > 20mm					-0.18*
Number days precipitation > 25mm	-0.025				

Extremely wet days (mm)			1.47		
Annual precipitation total (mm)				-3.17	-9.79*

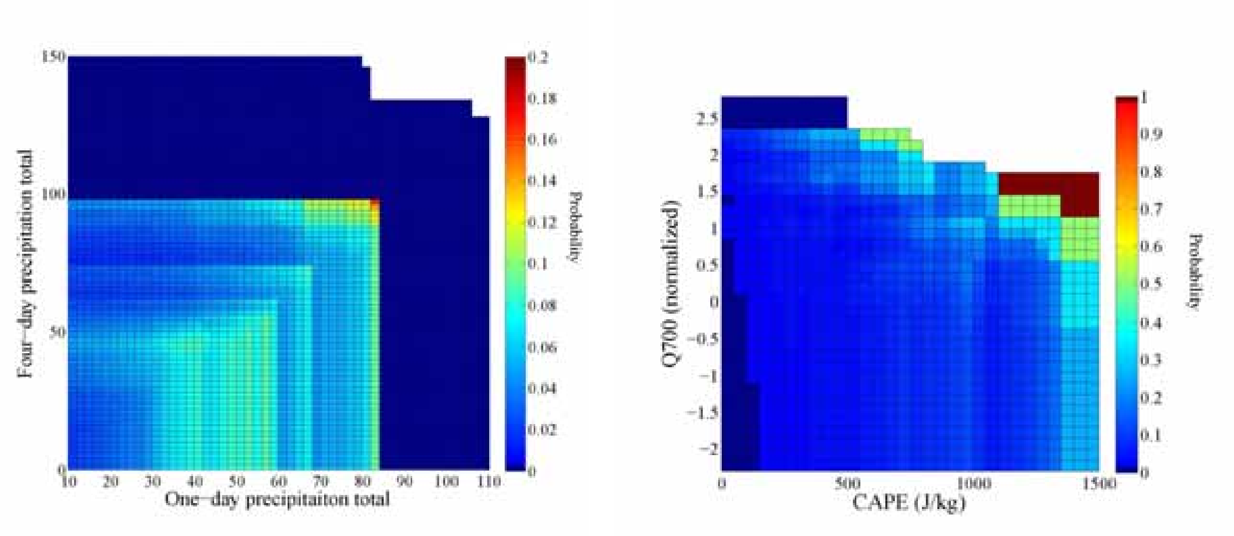
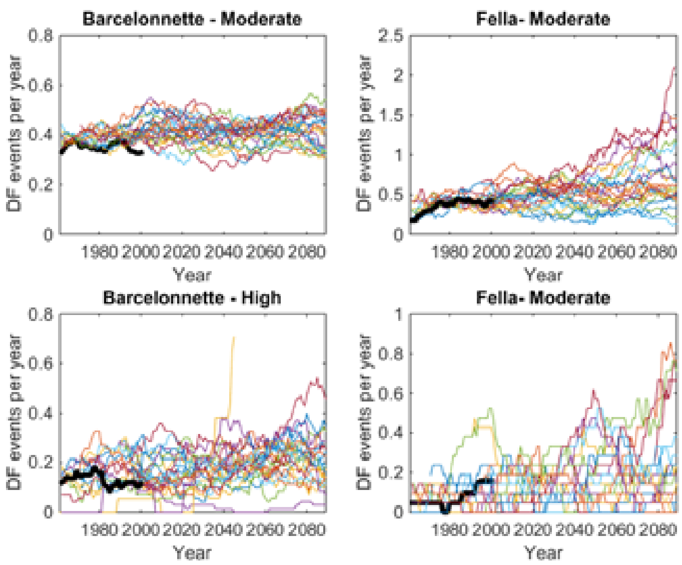


Figure 3: Probability of a flash flood or debris flow in the Ubaye Valley based on 1- and 4-day precipitation (left), and atmospheric conditions – specific humidity at 700hPa and convective available potential energy (right). The red indicates a higher probability than blue, with dark blue indicating zero probability from empirical data (graphs from Turkington et al. 2014).

- Downscaling climate projections

It was expected during this phase of the research to review different statistical downscaling methods, select a couple of different techniques/predicting variables, and then aanalyse and compare the changes in different triggers. The time period considered would be for the observational period and up 2100 to determine the advantages and disadvantages of the different downscaling techniques for the research. This was undertaken in a third paper under preparation: Climate change impact on debris flow: the role of downscaling technique and meteorological trigger. Using different statistical downscaling techniques, global and regional climate models, projections and rainfall thresholds, the results showed that change in debris flows is sensitive to downscaling technique (Figure 2).
In a second paper along with ESR-02 (under submission), an automatic technique to separate flood events into meteorological-derived flood types was developed and evaluated for use in climate impact studies. Two study areas were considered, Ubaye Valley and Salzach, Austria. The second CHANGES study area Fella River, was not included, as there was insufficient discharge data. This paper deviated slightly from the original objective, as other papers had been published during the project covering the original objective.

Figure 4 Number of debris flow events per year based on different downscaling techniques, global and



2.2.3 Final reflection about the Marie Curie ITN

The Marie Curie ITN has provided an excellent opportunity to not only work towards a PhD, but gain a wide berth of skills not only relevant for academia, but in the private sector as well. The two main benefits were the research network and the training provided. The research network provided a good opportunity to work with other researchers, especially those in slightly different fields. Over the course of the project my ability to communicate with researchers in different fields greatly improved. This is something I feel I would not have obtained during a normal PhD. Secondly; the different training activities provided a balance to my research. I was forced to not only to consider the challenges and limitations for researchers in other fields, but also how my research would fit under the larger banner of risk assessments. The other ESRs also formed a good support group while undertaking a PhD. The extra funding for travel, research was a benefit allowing for more flexibility for attending conferences, training courses, etc. however, the Dutch regulations made it difficult to determine precisely what I could and could not do, as well as it took over a year after I started for my contract to be sorted out.

While overall experience in the project was positive, there were a few downsides. Secondments and other placements were with partner or associated partner institutes, which were not always well aligned with the PhD research goals (although there was a benefit working with researchers in other fields, see above). Furthermore, training activities and project reports could be viewed as a distraction from the PhD work. However, from my experience, unless an ESR has a very specific research plan and no desire to work in other fields, the advantages and challenges presented as part of the ITN far outweigh these potential downsides.

2.2.4 References

- Turkington, T., Ettema, J., Van Westen, C. J. & Breinl, K. 2014. Empirical atmospheric thresholds for debris flows and flash floods in the southern French Alps. *Nat. Hazards Earth Syst. Sci.*, 14**,** 1517-1530
- Zhang, X. and F. Yang (2004). RClimDex (1.0) User Manual. Downsview, Ontario, Canada, ClimateResearch Branch, Environment Canada.

2.3 Task1-3: Development and application of probabilistic models for flood hazard assessment at regional and local scales

<u>Final report ESR 02 (Korbinian Breinl)</u>

2.3.1 Main achievements

The main goal of this PhD research was to develop a new probabilistic multi-hazard flood modeling approach for urban areas that takes into account the hazard of fluvial and pluvial flooding as well as their joint probabilities of occurrence. Urban areas are often located on river floodplains and therefore prone to fluvial as well as pluvial flooding. It is assumed that the suggested approach is a valid attempt towards more comprehensive flood modeling techniques in urban areas.

To develop all required methodologies for the core topic of the thesis, two catchments were chosen for this research (Figure): the Salzach catchment in Austria and Germany with the catchment down to Salzburg (4,637km²), and the Ubaye Catchment in France down to the village of Barcelonnette (548km²). The Salzach catchment is located between 47.0° - 47.9°N and 12.0°-13.6°W with elevations from 400m.a.s.l. to 3,600m.a.s.l. The Ubaye catchment is located between 44.3° - 44.7°N and 6.6°-7.0°W with an elevation ranging from 1,100m.a.s.l. to 3,000m.a.s.l.

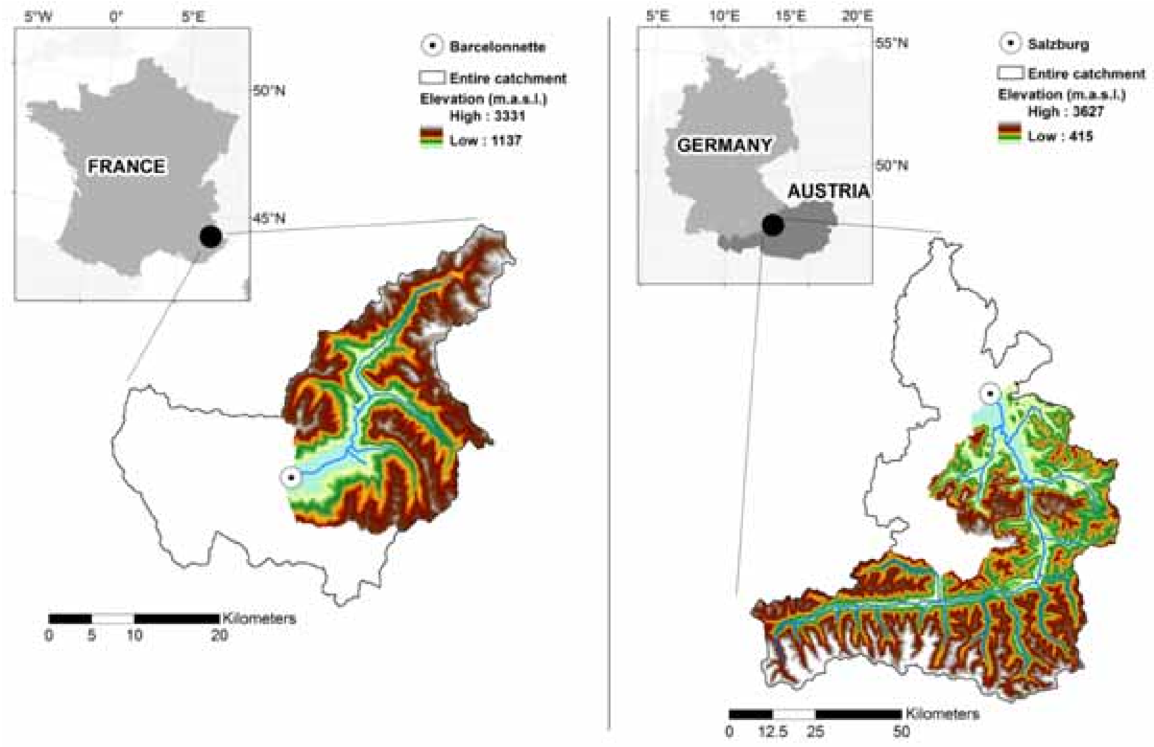


Figure 5: The study areas in France (left) and Austria (right).

Besides the hydro-meterological data, digital elevation data (SRTM-3) from the Shuttle Radar Topography Mission (Farr et al. 2007) were used to delineate the river catchments and to define elevation zones for distributed snow modeling. Fire service and insurance data used in this thesis were likewise used to derive critical rainfall thresholds.

This paper-based doctoral thesis comprises four ISI journal papers listed in Table 1, which represent chapters of this work. An additional fifth paper 'Paper*' in the Appendix of the thesis demonstrates another application of a stochastic weather generator, which is a key methodology of the thesis. The structure of the thesis and the role of the ISI papers are shown in Figure .

Table 1. ISI papers of the doctoral thesis

No.	ISI Journal Paper	Status
Paper 1	**Breinl, K.**, T. Turkington, and M. Stowasser (2013), Stochastic generation of multi-site daily precipitation for applications in risk management, J Hydrol, 498(0), 23-35.	Published
Paper 2	**Breinl, K.**, T. Turkington, and M. Stowasser (2014), Simulating daily precipitation and temperature: a weather generation framework for assessing hydrometeorological hazards, Meteorol Appl, n/a-n/a.	Published
Paper 3	**Breinl, K.** (2014), Driving a lumped hydrological model with precipitation output from weather generators of different complexity, Hydrological Sciences Journal, n/a(n/a).	Revised version submitted
Paper 4	**Breinl, K.**, U. Strasser, P. D. Bates, and S. Kienberger (2014), A joint modelling framework for daily extremes of river discharge and precipitation in urban areas (in review), Journal of Flood Risk Management, n/a(n/a).	In press
Paper* (Appendix)	Turkington, T., **K. Breinl**, J. Ettema, and V. Jetten (2014), Detecting future changes in flood types in Alpine Catchments, Clim Change, n/a(n/a).	Submitted

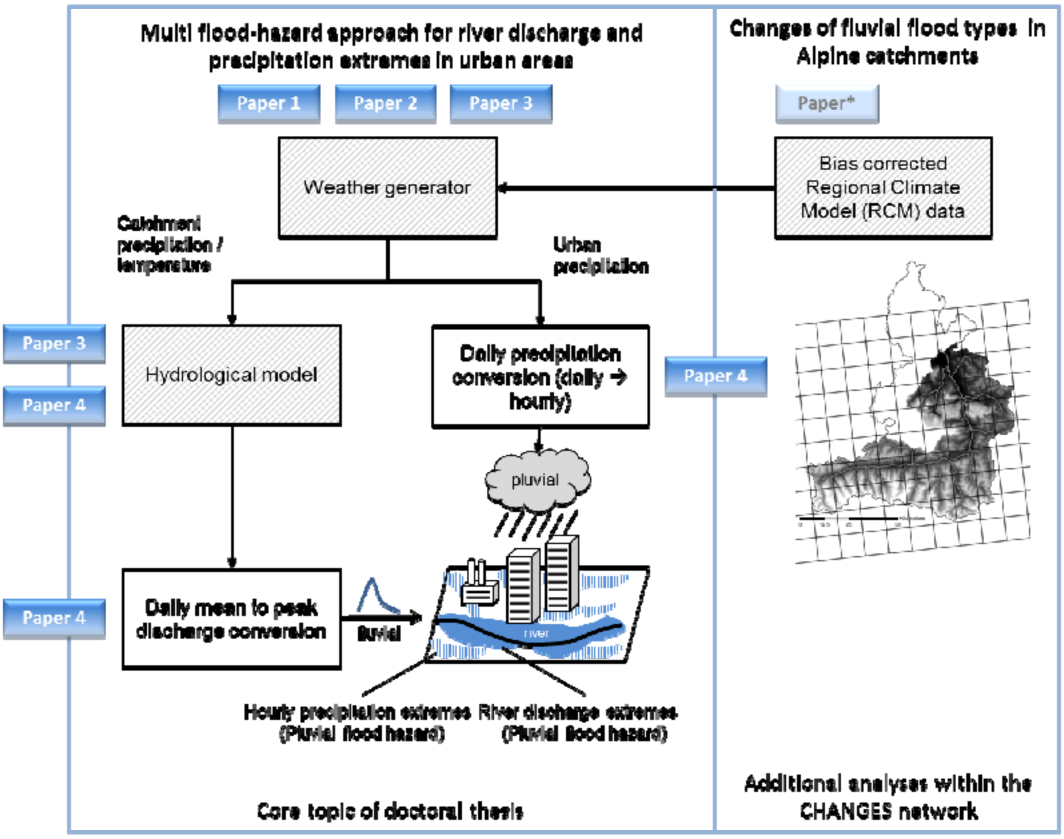


Figure 6: Structure of the doctoral thesis and the role of the ISI papers.

2.3.2 Abstracts

- **Paper 1: Breinl, K., T. Turkington, and M. Stowasser (2013), Stochastic generation of multi-site daily precipitation for applications in risk management, J Hydrol, 498(0), 23-35.**

Unlike single-site precipitation generators, multi-site precipitation generators make it possible to reproduce the space-time variation of precipitation at several sites. The extension of single-site approaches to multiple sites is a challenging task, and has led to a large variety of different model philosophies for multi-site models. This paper presents an alternative semi-parametric multi-site model for daily precipitation that is straightforward and easy to implement. Multi-site precipitation occurrences are simulated with a univariate Markov process, removing the need for individual Markov models at each site. Precipitation amounts are generated by first resampling observed values, followed by sampling synthetic precipitation amounts from parametric distribution functions. These synthetic precipitation amounts are subsequently reshuffled according to the ranks of the resampled observations in order to maintain important statistical properties of the observation network. The proposed method successfully combines the advantages of non-parametric bootstrapping and parametric modelling techniques. It is applied to two small rain gauge networks in France (Ubaye catchment) and Austria/Germany (Salzach catchment) and is shown to well reproduce the observations. Limitations of the model relate to the bias of the reproduced seasonal standard deviation of precipitation and the underestimation of maximum dry spells. While the lag-1 autocorrelation is well reproduced for precipitation occurrences, it tends to be underestimated for precipitation amounts. The model can generate daily precipitation amounts exceeding the ones in the observations, which can be crucial for risk management related applications. Moreover, the model deals particularly well with the spatial variability of precipitation. Despite its straightforwardness, the new concept makes a good alternative for risk management related studies concerned with producing daily synthetic multi-site precipitation time series.

- **Paper 2: Breinl, K., T. Turkington, and M. Stowasser (2014), Simulating daily precipitation and temperature: a weather generation framework for assessing hydrometeorological hazards, Meteorol Appl, n/a-n/a.**

Stochastic weather generators simulate synthetic weather data, while maintaining statistical properties of the observations. A new semi-parametric algorithm for multi-site precipitation has recently been published by Breinl (Breinl, K., Turkington, T. and Stowasser, M. 2013. Stochastic generation of multi-site daily precipitation for applications in risk management. Journal of Hydrology, 498: 23-35). Breinl et al. (2013) used a univariate Markov process to simulate precipitation occurrence at multiple sites for two small rain gauge networks. Precipitation amounts were simulated in a two-step process by first resampling observations and second, sampling and reshuffling of parametric precipitation amounts. In the present paper, the precipitation model by Breinl et al. (2013) is implemented in a weather generation framework for daily precipitation and temperature. It is extended to a considerably larger gauge station network of 19 stations and further improved to reduce the duplication of historical records in the simulation. Autoregressive-moving average models (ARMA) are used to simulate mean daily temperature at three sites. Power transformations reduce the bias of simulated temperature extremes. Precipitation amounts are simulated by means of hybrid distributions consisting of a Weibull distribution for low and a generalized Pareto distribution (GPD) for moderate and extreme precipitation amounts. The proposed weather generator is particularly suitable for assessing hydrometeorological hazards such as flooding as it reproduces the spatial variability of precipitation very well and can generate unobserved extremes.

- **Paper 3: Breinl, K. (2014), Driving a lumped hydrological model with precipitation output from weather generators of different complexity, Hydrological Sciences Journal, n/a(n/a).**

Hydrological impact assessment often requires coupling stochastic weather generation with hydrological modelling. Different stochastic weather generators of different levels of complexity are available. Univariate single-site models are very common but more suitable for small catchments where a single rain gauge adequately captures the catchment precipitation. However, in larger catchments, a strategy to overcome this limitation is averaging the records of various rain gauges and applying a single-site model to the resulting lumped precipitation time series. Multi-site weather generators can simulate more than one site but are more complex and often less intuitive. This paper deals with the question whether a lumped hydrological model driven with lumped daily precipitation time series from a univariate single-site weather generator can produce equally good results, compared to using a multivariate multi-site weather generator, where synthetic precipitation is first generated at multiple sites and subsequently lumped. Three different weather generators were tested, which were a univariate 'Richardson type' model, an adapted univariate Richardson type model with an improved reproduction of the autocorrelation of precipitation amounts, and a semi-parametric multi-site weather generator. Goodness-of-fit tests were applied to find the optimum parametric distribution functions for the simulation of precipitation amounts. The three modelling systems were evaluated in two Alpine study areas by comparing the hydrological output in regard to monthly and daily statistics as well as extreme flows. Although all three modelling setups can produce reasonable results, the application of a univariate Richardson type weather generator to lumped precipitation time series requires additional attention. Established parametric distribution functions for single site precipitation turned out to be unsuitable for lumped precipitation time series and lead to a large bias in the hydrological simulations. Such poor fits are very likely caused by the mountainous character of the two catchments examined, and thus by lumping precipitation time series that significantly differ (due to different altitudes and different site-specific micro-climatic conditions). The reduced autocorrelation of univariate Richardson type weather generators leading to a slight underestimation of (extreme) flows can be tackled by an improved simulation of the autocorrelation of precipitation amounts. Combining a multi-site weather generator with a hydrological model produced the least bias. Thus, there is a trade-off between the increased efforts of setting up such a multi-site weather generator, compared to implementing univariate models and the potential improvements of simulations.

- **Paper 4: Breinl, K., U. Strasser, P. D. Bates, and S. Kienberger (2014), A joint modeling framework for daily extremes of river discharge and precipitation in urban areas (in review), Journal of Flood Risk Management, n/a(n/a).**

Human settlements are often at risk from multiple hydro-meteorological hazards, which include fluvial floods, short-time extreme precipitation (leading to 'pluvial' floods), or coastal floods. In the past, considerable scientific effort has been devoted to assessing fluvial floods. Only recently have methods been developed to assess the hazard and risk originating from pluvial phenomena, while little effort has been dedicated to joint approaches. The aim of this study was to develop a joint modelling framework for simulating daily extremes of river discharge and precipitation in urban areas. The basic framework is based on daily observations coupled with a novel precipitation disaggregation algorithm using nearest neighbour resampling combined with the method of fragments, to overcome data limitations and facilitate its transferability. The framework generates dependent time series of river discharge and urban precipitation that allow for the identification of fluvial flood days (daily peak discharge), days of extreme precipitation potentially leading to pluvial phenomena (maximum hourly precipitation) and combined fluvial-pluvial flood days (combined time series). Critical thresholds for hourly extreme precipitation were derived from insurance and fire service data.

- **Paper 5: Turkington, T., K. Breinl, J. Ettema, and V. Jetten (2014), Detecting future changes in flood types in Alpine Catchments, Clim Change, n/a(n/a).**

An automatic technique to separate flood events based on meteorological-derived flood types is developed and evaluated for use in climate impact studies. High discharge days (Q2, Q10, and Q25) are separated into causal types using k-means clustering of relevant meteorological variables. Future discharge and flood types are then assessed from climate projections of temperature and precipitation, downscaled using quantile mapping. A weather generator is coupled with a conceptual rainfall-runoff model to create long synthetic records of discharge to increase the number of flood events. The technique is applied to two different catchments in the European Alps: the 548 km² Ubaye catchment in the southern French Alps, dominated by rain-on-snow floods during spring, and the 4637 km2 Salzach catchment in Austria, affected more by rainfall summer/autumn floods. The results show that, not only are there changes in frequency of floods, but also changes in seasonality and antecedent meteorological conditions. These results allow for a more focused discussion on reasons for changes in flood frequency linked to meteorological variables.

2.3.3 Main challenges

First of all, the data acquisition was a challenge. For instance, as there were no discharge data available (flow in m³/s) for the Italian study area, I had to come up with an alternative study area as I could not reliably calibrate a hydrological model. Second, it was challenging to reconcile the objectives of my own PhD research and the expectations in terms of the collaboration between the ESRs. I managed to work closely with ESR1 and exchange experience with some other ESRs but the time pressure and the complexity did allow me to work and publish even more. The project was very ambitious in this respect. Last but not least, I wanted to conduct hydraulic modeling to produce inundated areas for the Spatial Decision Support System (SDSS) but I could not finish it due to the time constrains. In general, a fourth funded year after meeting some requirements in the first three years (for example two ISI papers) would be extremely helpful and take the enormous pressure from the students.

2.3.4 Benefits from this Marie Curie Initial Training Network

The Marie Curie ITN was probably one of the most beneficial experiences I was allowed to make in the last years. I am deeply grateful. First of all, the international setup allowed me to become a much more open-minded person and grow as a person and not "only" as a researcher. The collaboration with 11 other ESRs from different countries was a fabulous experience. Second, I had the financial support and the time to develop my own ideas besides the project goals and grow from a less to an experience researcher. Third, the skill courses were extremely helpful to learn to think out of the box and to grow as a researcher. Last but not least, it was a great opportunity for networking and meeting interesting people and establishing relevant contacts for my future career. I want to take the opportunity here to thank my host institute, the coordinator Cees van Westen, the WP leaders, the other students and also the European Commission for this excellent opportunity.

2.4 Task1-4: Development and application of probabilistic models for mass movement hazard assessment at regional and local scales

Final report ESR 03 (Romy Schlogl)

2.4.1 Main achievements

The objective of this PhD thesis was to propose a quantitative assessment of landslide hazard (spatial and temporal probabilities of occurrence, intensity) from the analysis of a multi-date landslide inventory created with various data sources. The methodology associates the analysis of Earth Observation (EO) products and statistical modelling for the characterization of landslide hazard in a rural and mountainous region of the South French Alps (e.g. middle section of the Ubaye Valley: Barcelonnette Basin). The detailed objectives are:

(i) to update existing landslide inventory maps and create a multi-date landslide database of the Barcelonnette Basin from the interpretation of time series of SAR images, aerial photographs, geomorphological maps, historical reports and field surveys;
(ii) to characterize the spatial and temporal occurrences (displacement pattern, geomorphological evolution) and the intensity of the observed events;
(i) to identify relations among landslide predisposing factors and the landslide locations using statistical multivariate models;
(ii) to propose a quantitative assessment of hazards in a probabilistic framework for the creation of hazard maps.

The approach is multi-scalar as the methods have been developed at the slope (1:5,000-1:2,000) and regional (1:25,000-1:10,000) scales (see Fig. 1). The oldest archives available for this region are from 1850 whereas most of the geospatial data used in this research covers the period from 1950 to 2010.

The thesis is subdivided in four chapters (see Fig. 2) addressing successively (1) the definition, criteria and techniques for the establishment of a landslide inventory and the quantitative assessment of landslide hazard, (2) the physio-geographical settings of the study area and the observed natural hazards, (3) the multi-technique procedure to create the multi-date landslide inventory and (4) the forecast of landslide susceptibility and hazard through statistical models. This paper-based doctoral thesis comprises four ISI journal papers listed in Table 1, which represent sub-chapters of this work.

The **Chapter 1** provides a review of the concepts used for the detection and recognition of landslides and the procedures for landslide hazard assessment in relation with international standards and the French policy regulation for natural risk mapping. The mapping units are presented as well as the techniques for susceptibility zonation and hazard assessment.

The **Chapter 2** details the geographical, geomorphological and geological characteristics of the study area. The natural hazards observed in the region are presented with focus on some active and monitored landslides (La Valette, Poche, Les Aiguettes, Pra-Bellon, Adroit and Sanières)

The **Chapter 3** analyses the kinematics and the spatio-temporal distribution of the landslides at different scales. First, the kinematic of large landslides is monitored by the interferometric analysis of L-band SAR images at the slope-scale. Second, a multi-date inventory is created at the scale of the region by the visual interpretation of geospatial data, the analysis of interferometric phase values and the analysis of historical reports. The chapter is organized along a published manuscript and two manuscripts currently under review. The first two manuscripts are detailing a geomorphologically-guided methodology developed to interpret the kinematics of large and active landslides by using L-band (ALOS/PALSAR) imagery. Radar interferometry combined with *in-situ* measurements allowed us to define the deformation field of unstable areas and to detect new sliding zones. Then, the methodology of multi-date inventory preparation is described. Probability density functions are calculated in order to estimate area-frequency relationships. The temporal occurrence of landslides is estimated with a Poisson probability model to compute exceedance probabilities for different return periods.

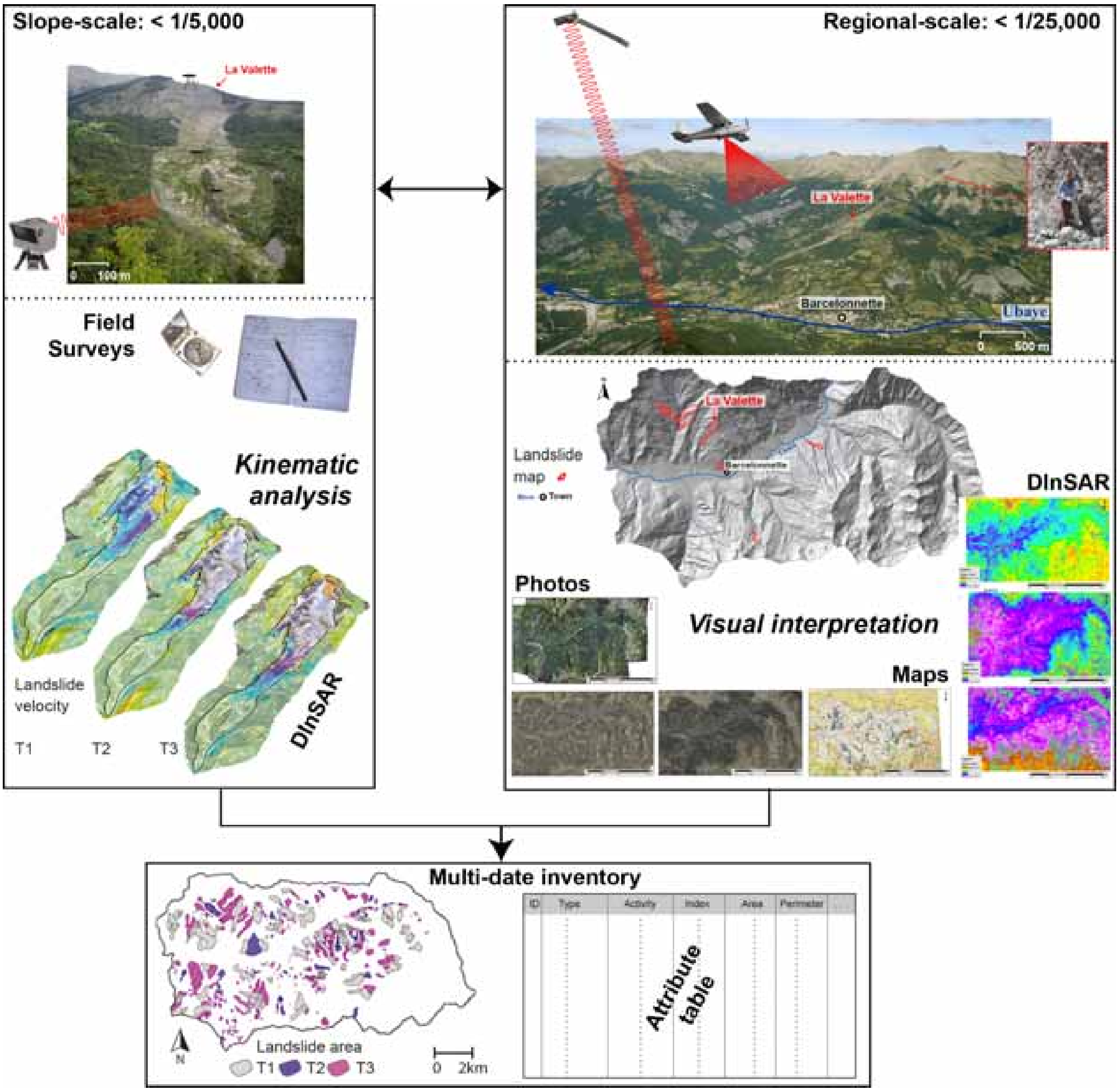


Figure 7: Combination of two analysis scales (slope, regional) for the creation of a multi-date landslide inventory for the Ubaye Valley (French Alps).

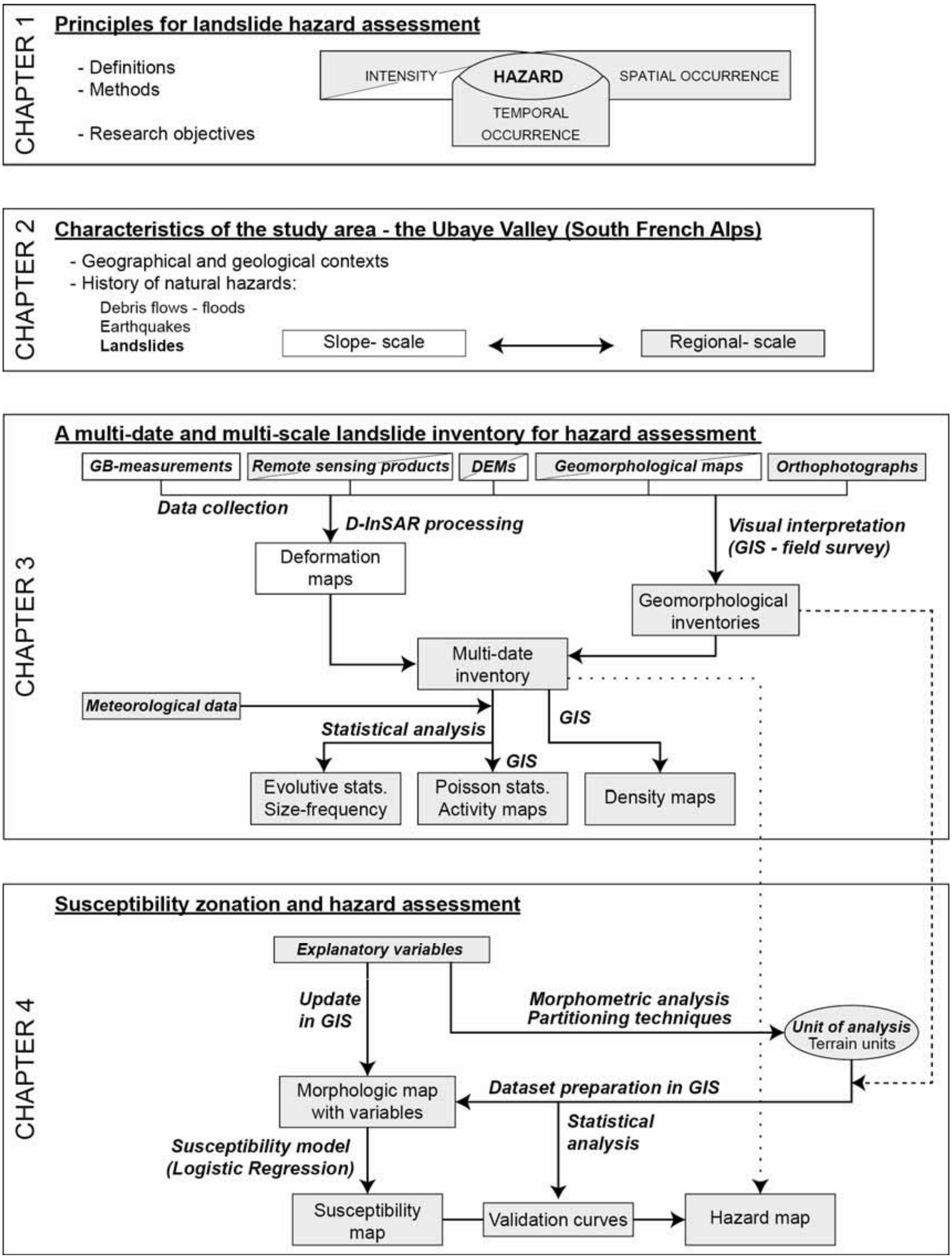


Figure 8: Content of the manuscript with Chapter 1 dedicating to the principles commonly used for hazard assessment, Chapter 2 focusing on the study area; Chapter 3 detailing the procedure of inventory creation, including InSAR interpretation and Chapter 4 estimating the susceptibility and hazard using different terrain units.

The **Chapter 4** forecasts the landslide susceptibility and hazard for the entire territory using several spatial units of calculation. A methodology to delineate the regions of interest into appropriate terrain units is proposed and tested. A logistic regression model is used to evaluate the spatial occurrence of landslides on the basis of several mapping units. Three statistical probabilities (spatial, temporal and temporal according to an intensity threshold) are examined to analyse the landslide hazard at regional scale (results of the spatial, temporal landslide occurrence obtained for the Ubaye valley). The results are discussed and compared on some local hotspots. A journal paper is still under preparation in collaboration with the CNR-IRPI team (Perugia, Italy).

Table 3. ISI papers of the doctoral thesis.

No.	ISI Journal Paper	Status
Paper 1	**Schlögel, R.,** Doubre, C., Malet, J.-P., Masson, F. (2015). Landslide deformation monitoring with ALOS/PALSAR imagery: a D-InSAR geomorphological interpretation method. Geomorphology, 231, 314-330. doi:10.1016/j.geomorph.2014.11.031	Published
Paper 2	**Schlögel, R**., Malet, J.-P., Doubre, C., Lebourg, T. (subm). Kinematic of Deep-seated La Clapière Landslide (Tinée Valley, Southern French Alps) monitored by D-InSAR and ground-based measurements. Landslides.	Submitted
Paper 3	**Schlögel, R.,** Malet, J.-P., Remaître, A., Reichenbach, P., Doubre, C. (subm). Analysis of a landslide multi-date inventory in a complex mountain landscape: the Ubaye valley case study. NHESS.	Submitted
Paper 4	**Schlögel R.,** Alvioli M., Reichenbach P., Malet J.-P., Rossi M., Marchesini I. (in prep). Terrain-unit delineation for landslide susceptibility assessment in a complex mountainous environment.	In prep

2.4.2 Abstracts

- **Paper 1**

Schlögel, R., Doubre, C., Malet, J.-P., Masson, F. (2015). Landslide deformation monitoring with ALOS/PALSAR imagery: a D-InSAR geomorphological interpretation method. Geomorphology, 231, 314-330. doi:10.1016/j.geomorph.2014.11.031

The objective of this work is to propose a geomorphologically-guided method for the interpretation of L-band ALOS/PALSAR interferograms created by Differential Interferometric Synthetic Aperture Radar (D-InSAR; see Fig. 3). The interferograms are used to estimate the deformation pattern of two rapid and large landslides (Poche, La Valette; South East France). The wrapped and unwrapped phase values are interpreted for different movement types (rotational, translational, and complex sliding) and two ranges of surface displacement rates. Kinematic sub-units are detected for both landslides, and zones affected by enlargement or retrogression are identified. The InSAR-derived displacement rates are consistent with ground-based measurements and with remote estimates of the displacement from C-band and X-band satellite SAR sensors. The results demonstrate the potential of L-band ALOS/PALSAR imagery for the monitoring of active landslides with important changes in the soil surface state and covered by vegetation.

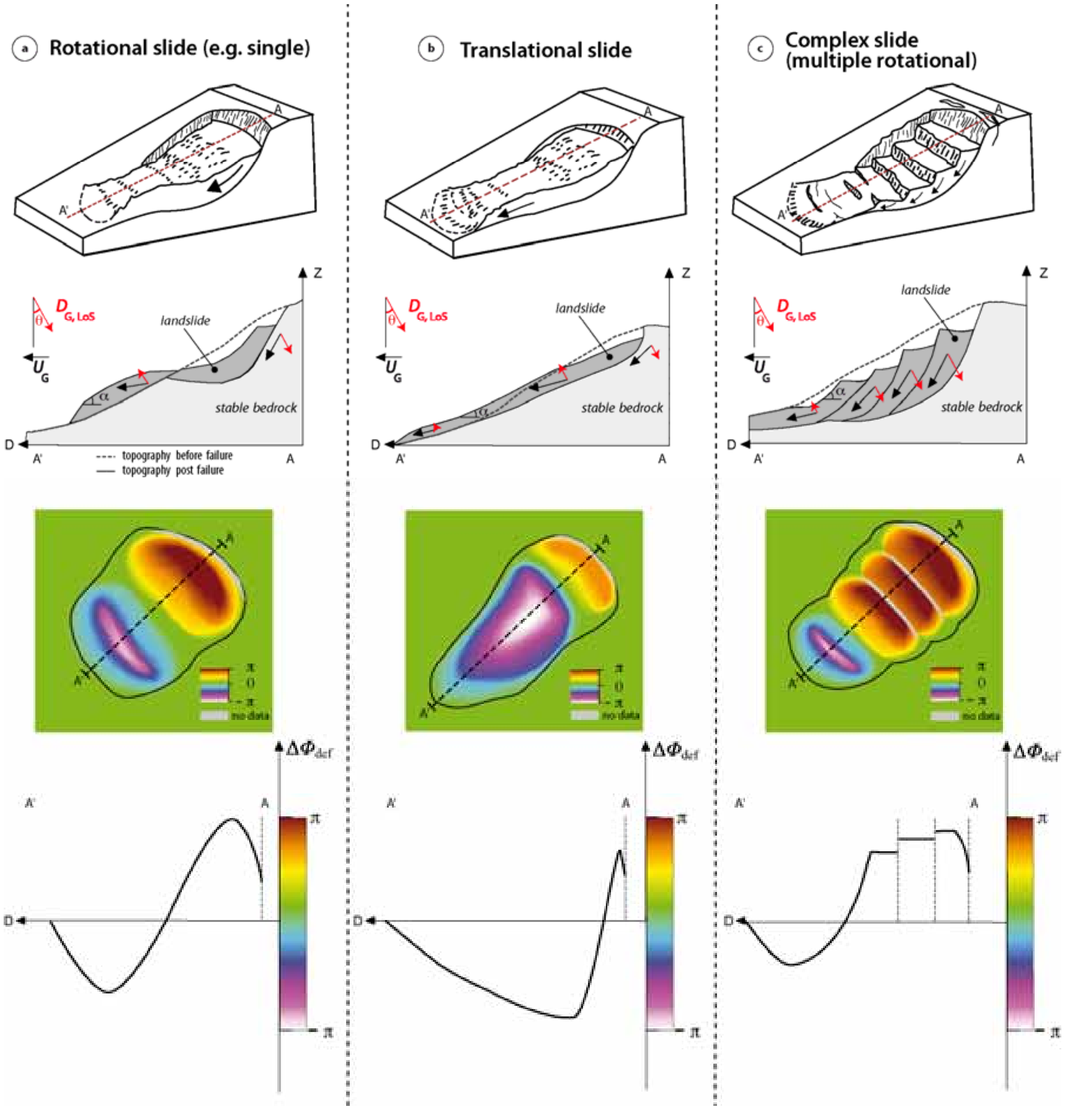


Figure 9: Displacement pattern, morpho-structures and associated interferometric phase for three landslide types (a) rotational slide with a single circular slip surface; (b) translational slide with a nearly planar slip surface parallel to the slope topography; (c) complex slide with a series of embedded circular slip surfaces. Three-dimensional view with a longitudinal cross-section of the slope morphology and synthetic distribution of InSAR phase values with longitudinal cross-section. The distribution of phase values is based on the following assumptions: (i) the SAR Line-of-Sight (LoS) and the landslide displacement directions are in the same vertical plane, (ii) the slope angle α is smaller than the SAR look angle θ, and (iii) the amplitude of the displacements are small enough to produce a phase variations in the interval [-π, π]. D: horizontal distance along the cross-section profile, Z: elevation; DG,LoS: displacement vector along the LoS direction, UG: displacement vector at the ground.

- **Paper 2**

Schlögel, R., Malet, J.-P., Doubre, C., Lebourg, T. (subm). Kinematic of Deep-seated La Clapière Landslide (Tinée Valley, Southern French Alps) monitored by D-InSAR and ground-based measurements. Landslides.

This research aims to document the deformation pattern of the deep-seated La Clapière landslide for the period 2007-2010 from the combination of L-band SAR interferograms, ground-based total station measurements and identification of the slope geomorphological structures. The interferograms are calculated for pairs of ALOS/PALSAR images at a time interval of 46 days, and are processed with the ROI_PAC and NSBAS algorithms. Phase unwrapping is carried out by integrating the daily surface displacement measurements on a series of 50 targets. The wrapped and unwrapped phase values are interpreted for different movement types (subsidence on top, accumulation at the base). The results demonstrate the potential of L-band ALOS/PALSAR imagery for the monitoring of active landslides characterized by a complex kinematic pattern and by important changes in the soil surface backscattering in time.

- **Paper 3**

Schlögel, R., Malet, J.-P., Remaître, A., Reichenbach, P., Doubre, C. (subm). Analysis of a landslide multi-date inventory in a complex mountain landscape: the Ubaye valley case study. NHESS.

We propose a methodology (1) to prepare a multi-date landslide inventory for a mountainous area affected by several landslide types with different degrees of activity, and (2) to estimate the temporal occurrence and the intensity of the landslides through the analysis of morphological indicators. The inventory, covering the period 1956-2010 (see Fig. 3), is constructed for the middle section of the Ubaye valley (South French Alps) based on the analysis of multi-source documents (geomorphological maps, historical reports of landslide events, field surveys, series of orthophotographs and SAR satellite images). The uncertainties in the interpretation of the documents and the landslide morphological features are taken into account in relation to the scale of the source documents.
Several morphological indicators are calculated to describe quantitatively the evolution of the landslides (length, area, relative elevation, runout distance). Frequency-area density functions are calculated to estimate the changes in the landslide distributions. A Poisson model is used to estimate the probability of reactivation of the observed landslides. The proposed multi-date inventory and the associated statistics give additional information to the event catalogue managed by local authorities.

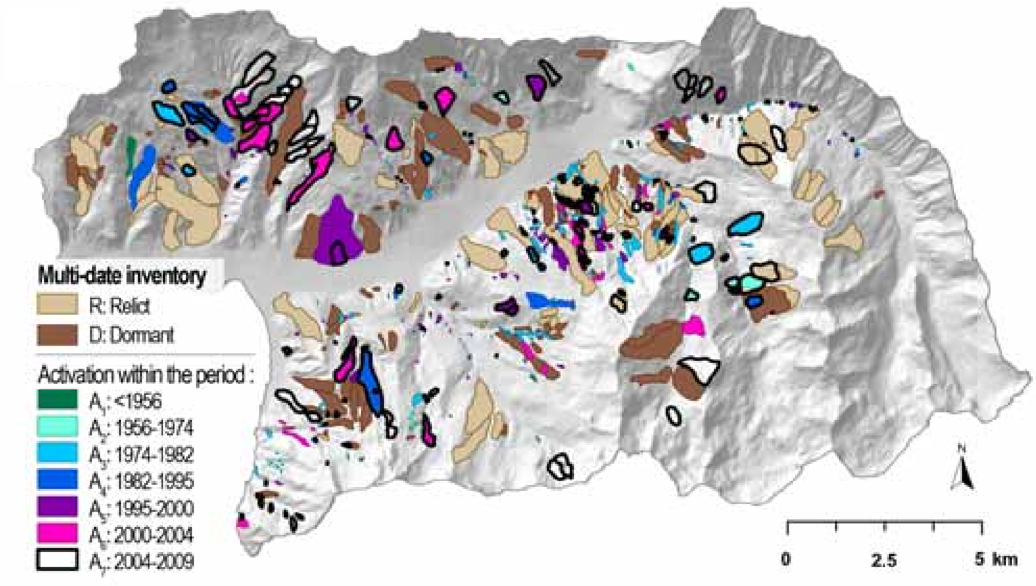


Figure 10: Multi-date landslide geomorphological inventory maps. Map indicating the landslide for different degree of activity (R: relict; D: dormant; A1-A7: active) for the periods A1 (<1956) A2 (1956-1974), A3 (1974-1982), A4 (1982-1995), A5 (1995-2000) A6 (2000-2004) and A7 (2004-2009).

- **Paper 4**

Schlögel R., Alvioli M., Reichenbach P., Malet J.-P., Rossi M., Marchesini I. (in prep). Terrain-unit delineation for landslide susceptibility assessment in a complex mountainous environment.

In this work, different partitioning methods of a territory are tested using different DEMs. First, terrain units were delineated based on unit size and hydrologic parameters in order to meet the local authorities requirements (i.e. a 1/10,000 scale of analysis). Second, slope-units (SU) were defined following the method proposed by Alvioli et al. (2014) without size constraints. These delineation methods are highly controlled by the quality and the accuracy of the DEM and by the complex morphology of the terrain (e.g. slope, shape of the valley, ruggedness). Third, an approach based on grid cells is tested. Then, using the three different mapping units, a logistic regression (LR) statistical model developed by Rossi et al. (2010) was used to evaluate landslide susceptibility zonation for both the landslide source areas and the whole landslide bodies on the basis of the different units of analysis. In the R-software, the regression model is fitted using iteratively reweighted least squares method under the link function (link=logit).

Results show that the relief of the area and therefore the mapping unit delineation are guided by the local geology or geomorphological setting of the landscape. Three DEMs of different resolutions (5 m, 10 m and 25 m) were exploited and the partitioning results into different units were compared. It shows that the 10-m DEM allows us to delineate the area into terrain units of homogeneous size fitting as possible to the hydro-geomorphology of the catchments. The SU results are analysed according to our knowledge of the landscape and in agreement with the properties of the 10-m DEM (e.g. resolution, quality). The following input parameters are chosen to delineate the Ubaye into SUs: a minimum area = 75,000 m^2; a circular variance = 0.175; a reduction factor = 100 and a threshold = 200,000 m^2. We selected heuristically these input parameters as they gave us the results fitting the best to our data of analysis (heterogeneous landslide size, mountainous conditions and DEMs properties. Many combinations of input parameters showed that changing the minimum and threshold sizes may affect a lot the delineation

Different landslide susceptibility zonations using logistic regression model were prepared using different mapping units obtained with the 10-m DEM. The results obtained with terrain units showed many false negatives and a strong influence of the elevation variable. The landslide susceptibility zonation obtained using the SUs provides good landslide prediction and less false negatives considering the entire landslide bodies instead of only the depletion area as dependant variable. Considering preliminary results, the areas under the ROC curve obtained are around 0.8 but an optimization of the input parameters (removing of elevation variable) would increase the performance of the model. Finally, LR regression was applied to grid cells using the same variable set. Performance of the different susceptibility models using different mapping units is discussed.

2.4.3 Main challenges

First, the DInSAR technique for landslide investigation has limitations due to several factors inducing high decorrelation of the signal, such as:

- The high velocity rates of sliding slopes (e.g. ablation zone of La Valette landslide);
- The combination of SAR and field properties, inducing deformation of the signal (layover) according to the orientation and angle of some slopes;
- The presence of dense vegetation (even with L-band sensor);
- The changing climatic conditions (e.g. presence of snow, intense rainfall);
- The temporal baseline which cannot overpass 46 days for quantitative kinematic analyses;
- The perpendicular baseline between some acquisitions (that we prefer below 1,200 m).

In addition, InSAR allows us to detect only active landslides. Therefore, it cannot be used to create landslide event inventories. In this study, InSAR signals corresponding to active portion of landslides are remapped at higher resolution (i.e. 1:3,000) according to the geomorphology of the terrain. These new polygons, which reflect active landslides, are introduced in the 2009 geomorphological inventory. Unfortunately, due to SAR geometrical properties (layover, hidden slopes), they do not constitute a full inventory of active movements of the region for one period. Due to the difficulties encountered to map and analyse landslides using this technique, this part of the work took more time than expected occurring a delay in the further expectations.

Second, the preparation of the multi-date inventory from multi-source data was a challenge. For instance, the area of interest (Ubaye Valley) was extended to map the landslides covering around 260 km^2, requiring many field surveys. This geomorphological inventory contains 788 slides corresponding to an average density of ca. 3.4 landslides per square kilometre. 59 slides are relict, 115 slides are dormant and 614 slides are considered as active, which represent respectively, 7.1%, 5.8% and 7.1% in relative percent of the study area. Landslide susceptibility zonation maps and landslide hazard forecasts are only preliminary results because of time pressure. I know that they could be improved by considering other input parameters and thresholds; that is why I decided to continue working on this topic in order to complete the study and provide relevant results.

2.4.4 Benefits from this Marie Curie Initial Training Network

The Marie Curie ITN was definitely one of the most beneficial experiences I could benefit in the last years. It was a great opportunity for networking and meeting interesting people and establishing relevant contacts for my future career. First, the international setup helps me to open my mind, be more curious and critical as a researcher but not only. Unfortunately, I was not able to collaborate as much as expected with the other 11 ESRs. Second, I had the financial support and the time to develop my knowledge in a topic I am passionate about. Finally, the skill courses were very interesting to grow as a researcher in an international environment. I am deeply grateful to all the people who helped me to complete this demanding PhD. I thank my host institute, the coordinator Cees van Westen, the other ESRs such as the European Commission for this great opportunity which is a milestone in my life.

3. Main results in relation to general objectives of WP2

Objective

The aim of this Work Package was to evaluate environmental changes, triggered by global change (including climate change) and interacting with economic development, leading to changes in exposed elements at risk. The assessment of former distributions and the characterization and analysis of the current exposed elements at risk will form the basis of the work. Future scenarios for the location and type of exposed elements at risk depend on a number of factors, which are related to global change, but also to future economic developments and implementation of policies for land use planning. The vulnerability of the society to flooding is generally much better understood and characterized than for landslides. The uncertainty level in vulnerability approaches should be evaluated based on historical damage catalogues, modeling and expert opinion. Indices for comprehensive, or holistic vulnerability assessment that include uncertainty levels will also be analyzed and integrated within a dynamic context, focusing on characterization of future changes.

3.1 Task-2.1: Assessment of the current vulnerability situation based on historical developments.

This has resulted in the deliverable: D2.1 Assessment of the current vulnerability situation based on historical developments, which was finalized at M+16.. The delivery is a report on the different approaches used in vulnerability assessment for hydro-meteorological hazards, such as floods and landslides.

3.2 Task2-2: Analysis of expected changes in ecosystems and land use patterns in relation to global change and future socio-economic development

<u>Final report ESR 04 (Žiga Malek)</u>

3.2.1 Main achievements

This research is divided into several steps. The first step of the research was the analysis of past land changes and driving forces in the two study areas. It contributed to the knowledge of how socio-economic changes in transient regions can influence land changes. The novelty of the approach lies in the combined quantitative and qualitative approach. Using remote sensing and GIS techniques to observe past changes is an established approach, which however usually does not address the reasons behind these changes. The driving forces of land changes in areas in a socio-economic transition are difficult to study due to the lack of data and complexity of these issues. Besides, mountain areas are regions where the prevailing driving forces of land use change can be external, and therefore not obvious when investigating them with available statistical data, which are commonly focusing on the respective region and not on the surrounding influencing areas. The qualitative part of the research refers to interviews. The results helped to understand the causes behind land use changes in these two areas in more detail. Moreover, the research showed the differences between the observations on land use changes by the researcher and the perceptions of the stakeholders – these differences are usually not addressed. It also revealed the driving forces of land use change which cannot be handled by the local decision makers and can thus result in land management difficulties, and even conflicts.

The second step was the participatory development of scenarios. Involving stakeholders by performing interviews, discussions and workshops has become an established method in scenario development. Their involvement is however usually limited with providing their visions on future plans or amounts of land change. This research aimed at a higher level of stakeholder involvement. By developing expert based belief systems – cognitive maps – stakeholders' knowledge shaped the conceptual models and the individual components of the spatial allocation models developed in the subsequent steps. Supported by local knowledge, the whole modelling procedure and the resulting scenarios could therefore be considered as more plausible and relevant for the stakeholders.

Moreover, the approach identified the possible set of options the local and regional stakeholders have to manage potential future land changes and their consequences.

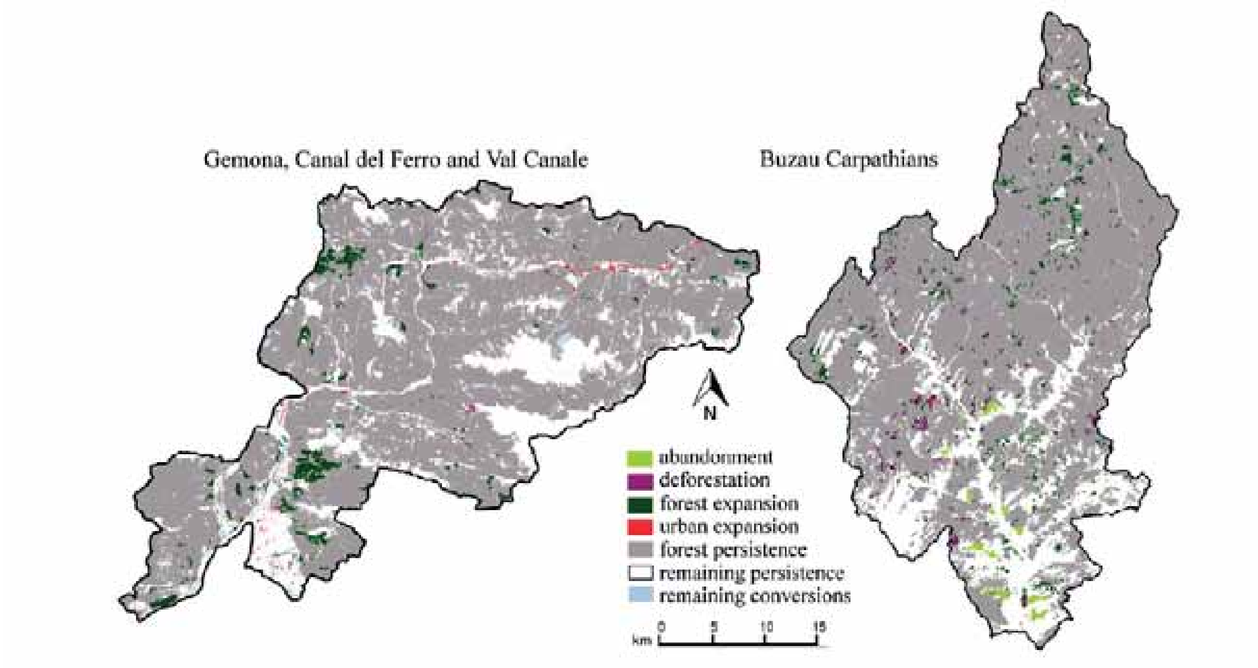


Figure 11 Spatial distribution of land cover conversions between 1989 and 2010. (Malek et al.2014)

The spatial allocation of scenarios using GIS and geosimulation was the next step. The spatial simulation approach applied in this research was embedded in the participatory-geosimulation framework. This way, the developed future storylines were translated to spatially explicit scenarios that took into account local scale specific environmental and spatial characteristics. The approach can be replaced by a different spatial allocation procedure in case different data (more or less data available) or processes are studied. The cellular automata (CA) allocation algorithm calibrated with past observations and physical-geographic characteristics also resulted in a study area specific and more realistic spatial pattern of change. Pure CA models fail to capture the amount of future land change as a consequence of future human decision and socio-economic development. Combining spatial simulation models such as CA with participatory scenario development can however improve the relevancy and likelihood of the simulation. The applied approach also provides the information on the uncertainty of the model. When modelling future scenarios, this information is often omitted. Scenarios are based on future assumptions and are usually presented as creative visions of the future. Still, providing the information on the success rate of the model taking into account both the uncertainty of the data and the model, improves the transparency of the simulation. This way, it is clear that spatial simulation (at this stage) cannot be used for prediction of exact locations of land change. Due to the relatively high likelihood of capturing the spatial pattern of future changes, it can however be applied for identifying hot-spots of change (e.g. particular catchments or slope classes) or comparing different future scenarios and evaluating decisions.

The next part - the GIS assessment - presents both the possible consequences of future land changes as well as the applicability of the proposed scenario development framework. As already mentioned, spatially explicit studies of environmental consequences of future development are rare. Like the spatial allocation step, the assessment part was also shaped by the characteristics of the study areas and data available. This way it demonstrated the possibility to evaluate different scenarios in terms of consequences for the provision of ecosystem services, or changes to landscape and hydro-meteorological risk. Moreover, the resulting maps of future distributions of consequences of land changes can help to communicate the potential consequences of future land changes.

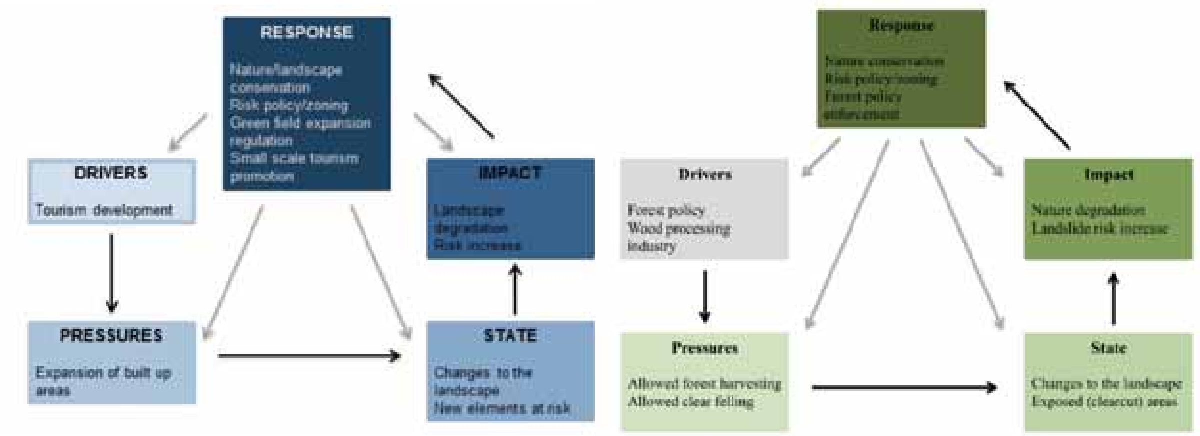


Figure 12 Drivers – Pressures – State – Impact – Response conceptual model of future urban expansion due to tourism development in the Italian study area (left) and the Romanian study area (right)

Finally, the methodology developed in my part of the ITN is novel in the way that it was developed and applied in two different study areas: Italian Alps and Romanian Carpathians. Both are mountain areas with complex socio-economic and physical geographic characteristics, and are subject to hydro-meteorological risk. They are however experiencing different processes of land change and are characterized by different data availability. Other studies on future land change in the mountains have developed approaches with better estimated performance of the spatial simulation. Still, those approaches are usually tailor made for specific study areas and thus not transferable to other regions.

3.2.2 Main challenges

- Data

One of the main challenges was the lack of data. In mountain areas, driving forces of land use/cover change can mostly be external and thus already not covered in accessible data, or they are difficult to quantify. Due to the lack of data, more time had to be spent on gathering and analyzing the data, which could be spent better on developing a land use/change simulation model or future scenarios. Already working in two study areas demanded more time. A sometimes complete lack of high-resolution data (local level) on a high temporal resolution (at least every 5 years) therefore demanded to spend additional time on field work and desktop based data generation. On the other side, as most of the data needed to be generated by Malek Ziga, he got to know both study areas better thus leading to a more informed development of a simulation model.

- **Risk integration in land use/cover change modeling**

The CHANGES project aimed at an integrated risk analysis framework. Sadly, due to several objective constraints this was not fully possible. One example is, that all PhD students started at the same time, thus limiting the development of a land change model, that would already take into account future changes to floods, landslides, and vice versa – for example a flood model that would already take into account future land use changes. Despite the fact, that the simulated model did take into account potential changes to future risk, and was shaped by the demands of the risk community (high temporal and spatial resolution, land change processes of interest to the risk community), the modeling framework of all researchers was not fully integrated (in some case it was not integrated at all).

One example of this integration is a hypothetical urban expansion model. The demand part of the model would calculate a higher demand for urban areas, which would then need to be allocated by the spatial allocation part. In case the flood/landslide risk model was integrated in the urban expansion model, the allocation model could allocate future urban expansion on areas only in case this would not result in an increase to risk. This way, the model could test successful decision making, and could propose areas where development would not result in a risk increase.

- **Different study areas**

It was very challenging to work in two study areas. Some PhD students think that the 4 study areas proposed in the beginning of the project were too optimistic, due to the lack of data in at least 2 of them. Therefore, Ziga Malek focused on one area with sufficient data and on one with barely any data. This took a lot of time not only due to the data, but also due to the necessary involvement of stakeholders from both study areas. On the other side, this research is also more applied, as in the real world we often face a situation, when the data is not available and we need to make decisions based on what is available. Therefore, the research of Ziga Malek also shows, how a best case study area (in terms of comprehensive data sets) differs from a worst case study area (in terms of few data). This has indeed also implications on decision making.

3.2.3 Benefits from this Marie Curie Initial Training Network

- **Skills**

The ITN network consisted of high level research institutions from all around Europe that are in my opinion the best in terms of risk research. Thus, the ITN enabled me to develop interdisciplinary skills in the field of risk. These skills ranged from:

- Theoretical background in human and physical geography,
- (Mountain) geomorphology and climate change
- Geographic Information Systems (GIS)
- Geo-informatics and web based technology
- Spatial planning and land management
- Risk and environmental legislation
- Environmental simulation (modeling)
- (Geo)statistics
- Game playing and development
- Disaster preparedness and management

Moreover, throughout these 3 years Ziga Malek was also lucky enough to improve his soft skills, such as workshop organization, contacting stakeholders and performing interviews, organizing field work, time management, improvisation, working in a multicultural and multilingual environment. This ITN truly was an experience that substantially shaped his professional and personal development. He is positive that the whole ITN with its main deliverables (us researchers) is a valuable contribution for future risk research.

- **Contacts and courses**

Throughout the last 3 years, Ziga Malek developed a wide, international network of contacts from numerous countries from all continents. On the account of the ITN, he personally established more than 200 valuable contacts with experts from various fields, mostly with a focus on environmental changes, simulation and risk.

The ITN funds enabled me to attend basically any event (conferences, workshops, seminars, courses) in the field of risk and land use/cover change simulation. This way he was able to develop technical and personal skills needed for completing my PhD, and established a network of professional with complementary knowledge and capacity. He is positive this will enable him to pursue his professional interests in the field of simulating future environmental changes.

He attended numerous technical and professional skills course inside and outside the ITN. The courses included in the ITN itself were very helpful. Despite taking quite a lot of time in the course of last 3 years, he was able to develop a wider sense on what risk is, how it may change and how we can prevent/mitigate/omit it. Through the provided ITN courses, he was also able to see the role of a land use/cover change scientist in risk research. Surprisingly, land use/cover changes are often being ignored, or only statistical extrapolations are used in risk research, with climate change being in the main focus. Numerous research has however showed, that on a local scale, land use/cover change will be the predominant driver of change to hydro-meteorological risk, together with climate change. Moreover, both processes will exacerbate each other, making both aspects necessary when analyzing future risk.

This is what Ziga Malek liked most at this ITN: a more inter- and multidisciplinary approach on risk. Having 12 different research topics might seem chaotic and difficult to manage, however he believes that the ESRs have quickly recognized which of us will work together and which not. Some topics were not so deeply connected with his research topic, but some were very connected. In the end, he believes they all together have shown the numerous aspects of changes to risk, consequences to human activities and the potential for risk management.

3.3 Task2.3: Expressing uncertainties in vulnerability and value of infrastructure, buildings and land use to hydro-meteorological hazards

Final report ESR 05 (Roxana L. Ciurean)

3.3.1 Main achievements

The study 'Quantification of uncertainties in vulnerability assessment of infrastructure and buildings to hydro-meteorological hazards' is based on three main objectives. The first objective was to identify current research gaps that guide advancement of new methodologies of vulnerability assessment. Thus, a review of existent conceptual models was performed and, given the focus of the research, different physical vulnerability and uncertainty analysis approaches were classified, compared, and selected for further application. The results showed that numerous studies employ both qualitative and semi-quantitative methods for floods and landslide vulnerability assessments, however, quantitative studies are generally less common; and, in this latter category, even fewer are dedicated to landslide processes. Uncertainty in vulnerability assessments is quantified using statistical approaches as well as hybrid and qualitative models. Most papers acknowledge (or make use of) expert judgment (elicitation) as a complementary method during the analysis and interpretation phase. The review also show that the application of uncertainty analysis is hindered not only due to data quality/availability or model limitations but also due to difficulties in characterizing complex systems (mostly epistemic uncertainty is calculated while aleatory uncertainty is only acknowledged). However, the results of the uncertainty analysis are generally included in quantitative risk assessments (QRA) and thus, available for risk reduction strategies. In this review, special attention was given to methods developed in areas with limited data availability.

The first research objective enhanced the achievement of the second one i.e. the application of quantitative physical vulnerability methods (including uncertainty analysis) in two case study areas with different data availability, at local and regional scale. In both investigated areas, field- and desktop mapping was performed for developing elements at risk databases and collection of information regarding historical hydro-meteorological events. In Buzău County (Romania) a new semi-quantitative methodology was developed and applied for assessing physical vulnerability of buildings to landslides and floods at local scale. The novelty of this approach resides in the complementary use of quantitative (functions) and qualitative (indicators) vulnerability methods. The variability and transfer of vulnerability curves is initially addressed herein and resumed in later investigations. In Friuli-Venezia Giulia Region (Italy) physical vulnerability was quantified for both local and regional scales, using on one hand, debris flow intensity estimates obtained through dynamic run-out modeling, and on the other, detailed documentation of the 23 August 2003 debris-flow impact. The resulting vulnerability curves were validated against each other as well as compared with functions developed in similar environmental and socio-economic conditions. The research results were later included in a QRA performed by colleagues within the ITN. The analysis was produced in a GIS environment, and employed statistical analysis which is currently being completed with probabilistic modeling in order to improve the transparency and reliability of the results.

The achievement of the third objective of this research is currently ongoing. The focus is on evaluating the changes in exposed elements at risk and their vulnerability taking into account scenarios of land use change. If most of the previous studies considered vulnerability to be a static phenomenon, this study will show that both the built environment as well as the impacting processes not only change in time but also condition each other. The vulnerability of the built environment prior and post 23 August 2003 debris flow event in Italy is being assessed taking into account the construction of new structural mitigation works (e.g. check dams, retention basins), which results in modified levels of debris flow intensity and thus vulnerability and risk.

In the PhD research the Fella river area in Northeast Italy was studied. This study looked at 4778 buildings classified into six building material types and 16 occupancy types (Figure 10). Two seasons were taken into consideration to calculate the number of people inside the buildings, a touristic and a non-touristic season. The building values were obtained from the Italian Revenue Agency for the second semester of 2013. The buildings were classified per cadastral zone according to the Real Estate Observatory data. The minimum and maximum market value for each building was obtained by multiplying the corresponding land-use value (€/m2) with building area and number of floors. The final building footprint map contained the following attributes: location, geometry, number of floors, construction material, occupancy type and value. Figure 13 is an example showing the building economic values and number of people inside the buildings in the touristic season. Based on a literature study and expert based judgment, vulnerability curves were used for the different building types and for population inside the building types. Every modeled intensity exposed to a certain building is then related to a vulnerability value which is then assigned to each exposed building. Figure 14 shows a part of the town of Pontebba with the vulnerability value of buildings exposed to the three different hazard types.

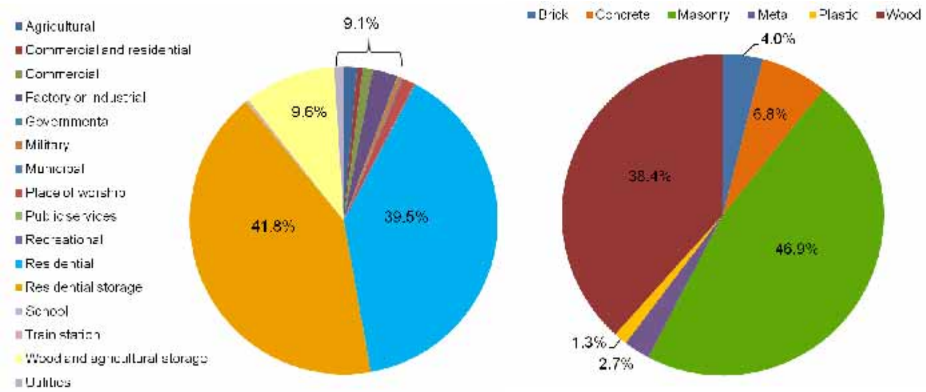


Figure 13. Percentage distribution of (left) building occupancy and (right) construction type in the Fella River Basin (Chen et al., 2014)

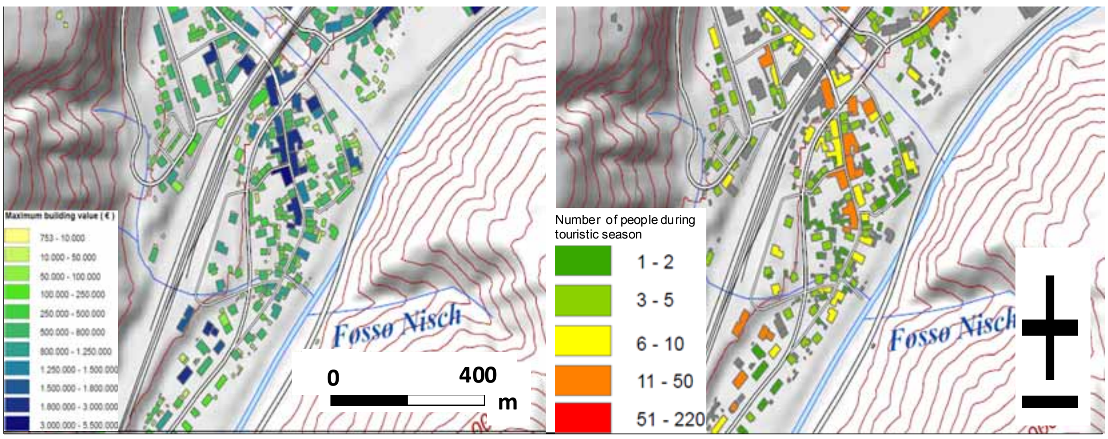


Figure 1. Topographic hill shaded relief map showing the distribution of (left) building value and (right) the number of people during the touristic season in the town of Pontebba.

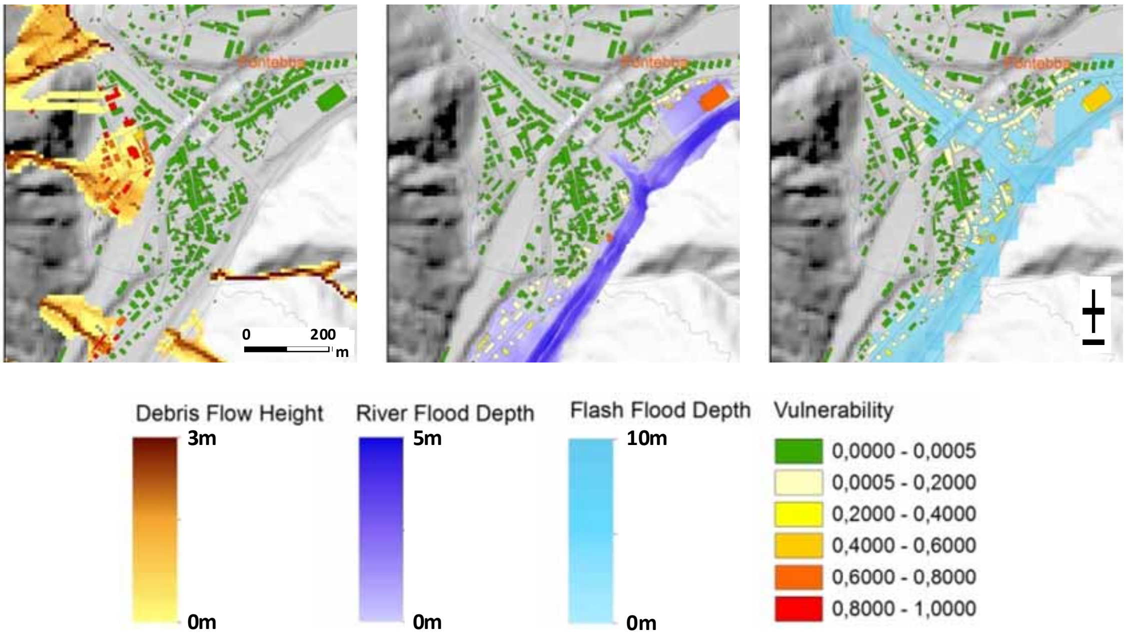


Figure 2. Example of building vulnerability to exposure to (left) debris flows, (middle) river flooding and (right) flash flooding in the town of Pontebba (Fella River Basin).

The research results obtained so far show that a methodological framework that accommodates both regional and local scale of investigations as well as scarce and rich data environments (i.e. Romania and Italy, respectively) has been developed and is currently being finalized. The conceptual framework operationalizes existent vulnerability and uncertainty models in a complementary manner (e.g. vulnerability curves with vulnerability indicators; confidence intervals with second moment estimates, and probabilities). Other achievements of this research work are: integration of results in other studies within the CHANGES ITN (e.g. ESR06 - probabilistic risk assessment, ESR09 - development and implementation of a Decision Support System for the use of risk information in risk reduction); and the production of research results (e.g. elements at risk databases, vulnerability curves, vulnerability maps) relevant for decision makers and risk managers in land-use planning, emergency management and risk prevention.

3.3.2 Main challenges

- **Development of the methodological framework**

One of the challenges Roxana Ciurean had to overcome at the beginning of her research was to identify the spectrum of research problems she is able to address successfully given the resources available (time, data, expertise) and project requirements (i.e. integrative research work through collaborations within the network). State of the art studies in natural hazards and risk indicate the need for a holistic perspective on vulnerability, that takes into account not only one (or separate) dimension(s) of vulnerability, but captures the complex relationships between these multiple dimensions (social, economic, political, physical, institutional, etc.). The idea of such an approach, although worthy of investigation, was not pursued directly in this research due to difficulties in quantifying uncertainty and changes in such complex systems. Instead, through permanent consultations with her peers and colleagues and a rather time consuming reflection process the methodological framework of this work was built on a much more focused research problem (quantification of uncertainty in physical vulnerability of the built environment only) in such a way that the above mentioned conditions are met.

- **Data availability and quality**

Another challenge that she had to overcome was the limited availability of data for performing the vulnerability analysis in one of the two case study areas (i.e. Buzău County, Romania). Although this is a generic problem in natural hazards and risk research (reflecting the reality of different socio-economic and environmental settings around the world), most of the vulnerability studies are heavily conditioned by the type, quality, and quantity of existent information about the characteristics and spatial distribution elements at risk, damage data, and historic catalogues of hazard events and their magnitude/intensity. The scarcity of such data represents a real challenge for quantitative studies and must be compensated with time consuming field work (data collection from different institutions, surveys, etc.) or desktop mapping, especially in cases where more than just one spatial scale of investigation is selected (herein, local and regional). Even in the case of the Italian case study, where basic information was present, detailed field work campaigns were necessary for the improvement of the database and application of empirical/statistical methodologies. Nevertheless, the data collection phase was a learning process that helped me understand how to manage time and other resources and how to conceptualize a vulnerability assessment methodology for a specific data environment.

- **Integration of results within the CHANGES risk management framework**

One of the main objectives of the CHANGES ITN was to design an integrative methodological framework for risk management of hydro-meteorological hazards taking into account global changes (environmental and climate change as well as socio-economical developments) i.e. different risk management components had to be connected and support each other's development in a process-like manner. However, all ESRs started their research in the same time and the design of each individual research work (component) had to be developed taking into account (where applicable) the integration of the output results in the general risk management process. Vulnerability being one of the key components in this framework, it was important for her to develop a collaborative work with hazard and risk analysts (interactive meetings during the secondment periods were very useful in for this objective). Moreover, providing data input (e.g. elements at risk information, vulnerability data) for the development of the SDSS was also possible. Nevertheless, due to timing conflicts, she was not able to use for example the landuse scenario modeling results which would have given her the opportunity to investigate changes in elements at risk and their vulnerability on a wider temporal and spatial scale.

- **Finalization of her PhD research project within 3 year**

Considering the challenges mentioned above, and the fact that my actual research work in the CHANGE Project started in the same time as the end of my M.Sc. studies, I was not able to conclude my PhD studies at the end of the CHANGES Project. Thus, the finalization of my studies will take place in the following months, through the financial support of a mobility grant of the University of Vienna and the supervision and guidance of Prof. Dr. Thomas Glade (UNIVIE), thesis coordinator and main supervisor, and supporting supervisor of Prof. Dr. Michel Jaboyedoff (UNIL).

3.3.3 Benefits from this Marie Curie Initial Training Network

Being part of the CHANGES ITN had a significantly positive impact on her professional and personal development. Professionally, she improved my analytical thinking, enriched my skills and competences, developed a solid expertise in natural hazard risk research (specifically on vulnerability assessment), created a professional network in academia and industry, and benefited from inter-disciplinary work in a highly qualified research environment.

More specifically, in the last three years she has participated in numerous courses within the CHANGES ITN and outside the project that enabled her to gain theoretical and practical knowledge in the field of vulnerability analysis and disaster risk management, environmental changes, spatial planning and risk governance. She has learned to develop and structure a research plan, write research proposals, and project management. She improved her technical skills in GIS and statistical modeling which served as tools for achieving my research goals. As a member of the CHANGES ITN, she has been exposed and collaborated closely with world-wide recognized experts and researchers in the field of Disaster Risk Management, Geomorphology, Hydrology, (Engineering-) Geology, Climate and Environmental Sciences, Land use, Social Sciences; as a result, she has developed a multi-disciplinary perspective on vulnerability and risk assessment. One of the great benefits (but also challenges) of being part of a Marie Curie ITN was the mobility within the network. Being exposed to different research academic and private research groups helped her to understand how one can improve the collaboration links between the two sectors and better tackle the environmental problems she is trying to solve. Moreover, participating at conferences and workshops she was able to create numerous professional contacts outside the CHANGES network.

Personally, she developed a set of soft skills ranging from project management to research ethics, presentation techniques, etc. from which she benefited outside my professional environment as well. Being hosted for three years in Austria and living for short periods in other European countries contributed greatly to opening her cultural horizons and understanding of different social and economic contexts, in which she can now adapt more easily professionally and personally.

Lastly, but most importantly maybe, being part of the CHANGES ITN meant for her contributing to a new generation of early stage researchers that collaborate and evolve together. Their (frequent) meetings, talks, field work campaigns but also shared worries, challenges faced and small successes resulted in joint research work but also personal relations both of which hopefully will be continued in the future.

3.4 Summary of results and perspectives

In Work Package 2 (Evaluating changes in exposed elements at risk and their vulnerability) the following research results can be summarized:

- A methodology for evaluating environmental (land use/land cover) changes through scenario modeling taking into account climate and socio-economic changes
- Analysis of current and future exposed elements at risk (i.e. land-use classes at regional scale and buildings at local scale, for long and short term changes, respectively)
- A methodology for quantifying vulnerability of the built-up environment to floods and landslides, focused on the analysis of uncertainty and future changes in elements at risk and their vulnerability
- Through their activity, the Early Stage Researches have clearly demonstrated the capacity to valorize their scientific outputs at conference presentations, workshops, and project meetings. Their research results were acknowledged through peer-review in ISI and non-ISI publications as well as the successful defense of a PhD thesis (for ESR 04, Žiga Malek). For reasons mentioned above, the research work performed by ESR05, Roxana L. Ciurean, is still ongoing and expected to be finalized in the following months by summer 2015.

The Marie Curie Initial Training Networks offered the two ESRs recognized opportunity to improve their research skills, join established research teams and enhance their career prospects. Moreover, networking activities, workshops and conferences that involved research staff from the participating research establishments and external researchers were used in order to expand their professional network and thus, achieve one of the goals of the CHANGES ITN, i.e. offer the best possible conditions for creating a new generation of highly qualified European scientists.

4. Main results in relation to general objectives of WP3

The aim of Work Package 3 was to integrate the techniques for probabilistic hazard assessment designed in WP1, that incorporate the increased uncertainty due to future environmental changes, and societal concerns, with the results of the exposure and vulnerability analysis of WP2, into a platform for Quantitative Risk Assessment (QRA) using probabilistic multi-hazard risk assessment techniques. The activities summarized in Figure 16 were carried out by ESR06 and ESR07 with significant collaborations with ESR01, ESR02 and ESR03 (WP1) and ESR04 and ESR05 (WP2). Methods that are used for probabilistic risk assessment for other types of hazards (e.g. earthquake, windstorms, and hurricanes) were analysed to evaluate their applicability in flooding and mass movement risk assessment. Approaches for probabilistic risk assessment that will be developed and applied require large number of (spatial) data, coming from different data providers and sources. Therefore an important component consists of the formalization and organization of datasets that can be used for the risk assessment models as well as for integrated risk management. During the project, a platform has been designed using Open Source software which can be accessed through a web portal.

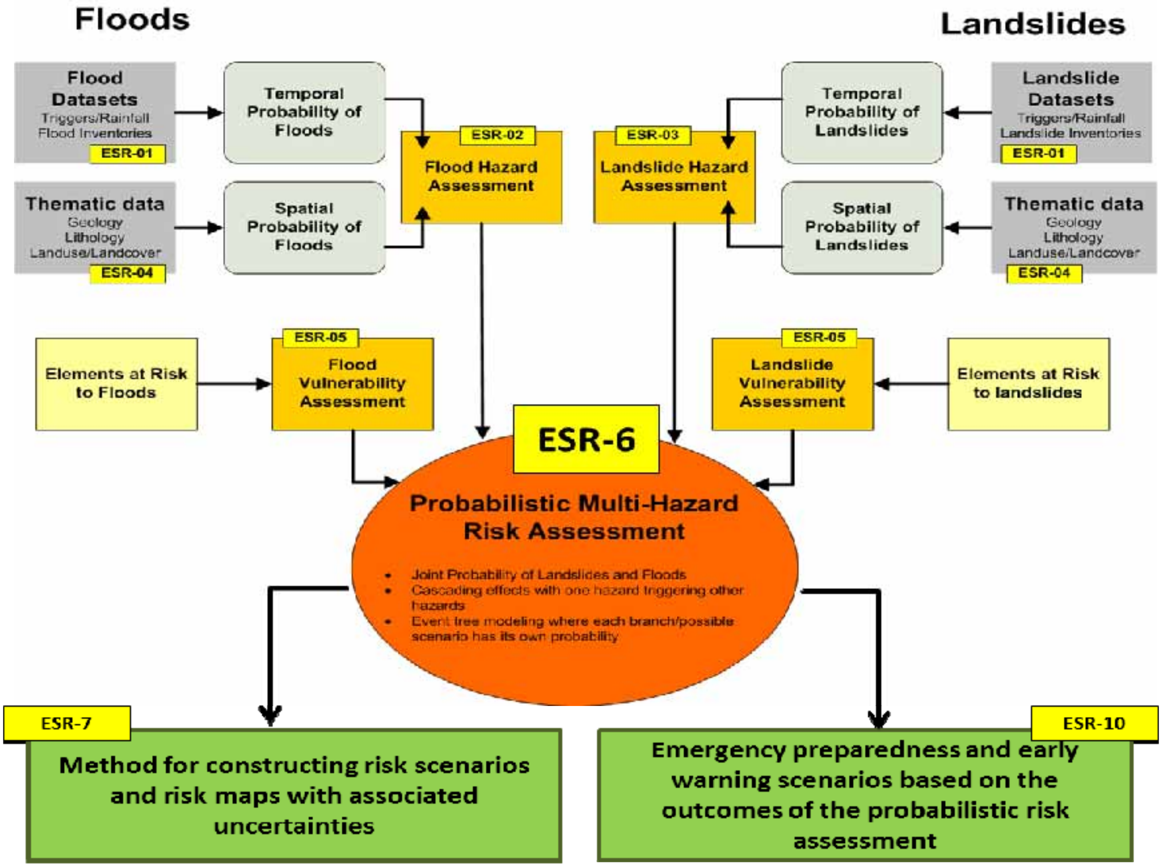


Figure 16:. The flow chart shows the integration between ESRs activities.

4.1 Task3.1: Inventory of existing software tools for probabilistic risk assessment, and their applicability in a European context.

Task 3.1 has been completed and existing software tools for probabilistic risk assessment have been analyzed to highlight their applicability in a European context. In fact over the last few years, a various quantitative/probabilistic hazard and risk assessment have been developed, including open access and open code software applications. Depending on the initial motivation for their development, the different tools comprise different philosophies and functionalities. In the deliverable 3.1, the information regarding software tools was collected and analysed with regard to the required input data, hazard and vulnerability/risk modules, transparency of methods and validation/calibration and their vintage/state of the art, to mention the most important criteria. Some tools such as Hazus-FEMA were reviewed by applying the software, other tools such as HazYemen were only reviewed by reading manuals or other descriptions of their functionality as they were not accessible at short notice and without major applications to the developers. A special focus was on the applicability of the tools to European test sites in general (some have originally been developed for the application in other regions) and hence their usefulness for the ‘Changes’ project in particular. This review has also been presented by ESR-02, ESR-06 and ESR-07 to the scientific community as a poster contribution at the EGU conference 2012 in Vienna.

4.2 Task3.2: Risk assessment of hydro-meteorological hazards, using a multi-hazard approach.

Final report ESR 06 (Haydar Hussin)

4.2.1 Main achievements

The aim of this research was to develop and combine methods for quantitative risk assessment (QRA) of multi-hazards occurring in mountainous environments, which are areas well known for their rapid changes due to their climate, geo-environmental and anthropogenic settings. Research on quantifying multi-hazard risk is still relatively new, with many difficulties involved in the process. There is often a lack of quantitative data on single hazards, let alone multiple hazards occurring in the same location. Multi-disciplinary experts are needed to model different hazards and the numerous components of a QRA (e.g. temporal probability, hazard intensity, vulnerability, etc.). Methods are required to compare, rank and visualize multiple hazards in a clear and consistent manner in order to be used in assessing their risk. Addressing these problems are not only of scientific interest, but are essential for decision making, emergency preparedness and risk reduction strategies, among others.
This study was conducted in the Fella River Basin, an alpine valley system in the Eastern Italian Alps, where landslides and floods occur individually or simultaneously due to extreme rainfall triggering events. Part of the landslide hazard analysis was also compared with a second CHANGES-project study area, the Buzau County in the Romanian Carpathians. The research objectives were to gather and analyze sufficient multi-hazard data for the components of the QRA, to quantitatively model the hazards on both regional and local scales, to compare the loss estimation (economic and human lives) between the multiple hazards, to incorporate uncertainties in the QRA and to assess the temporal and spatial changes in risk due to hazard mitigation (residual risk) and climate change. At the end of this report, a list of publications is presented related to the content of this report.

Analysis of multi-hazard landslide data

An inventory of more than 1000 landslides was compiled in the Fella River Basin. This was accomplished using geomorphological and geological analysis, aerial image interpretation and existing multi-source data from the Geological Survey of the Friuli-Venezia Giulia (FVG) autonomous region, University of Trieste and landslide experts from the Research Institute of Geo-Hydrological Protection of the Italian National Research Council (CNR-IRPI). The most destructive and common type of landslide in the area are the debris flows followed by rotational/translational landslides and rock-falls.

Susceptibility mapping for landslide hazard analysis

Statistical landslide susceptibility modelling was carried out to identify the areas most prone to debris flow triggering and to use as input for landslide run-out analysis on a regional scale in the Fella River Basin. The modeling was also conducted in the Buzau County, Romanian Carpathians for shallow landslides to compare the performance and flexibility of the probabilistic Weights-of-Evidence (WofE) susceptibility model in two very different areas in terms of size, geo-environmental settings and landslide types. Two other sub-objectives were to study the effect of landslide sampling strategies and landslide sample sizes on the performance and prediction capability of the WofE model. Figure 4 shows the landslide susceptibility maps in both study areas.

The overall methodology of the medium to regional scale multi-hazard risk assessment is illustrated in Figure 17.

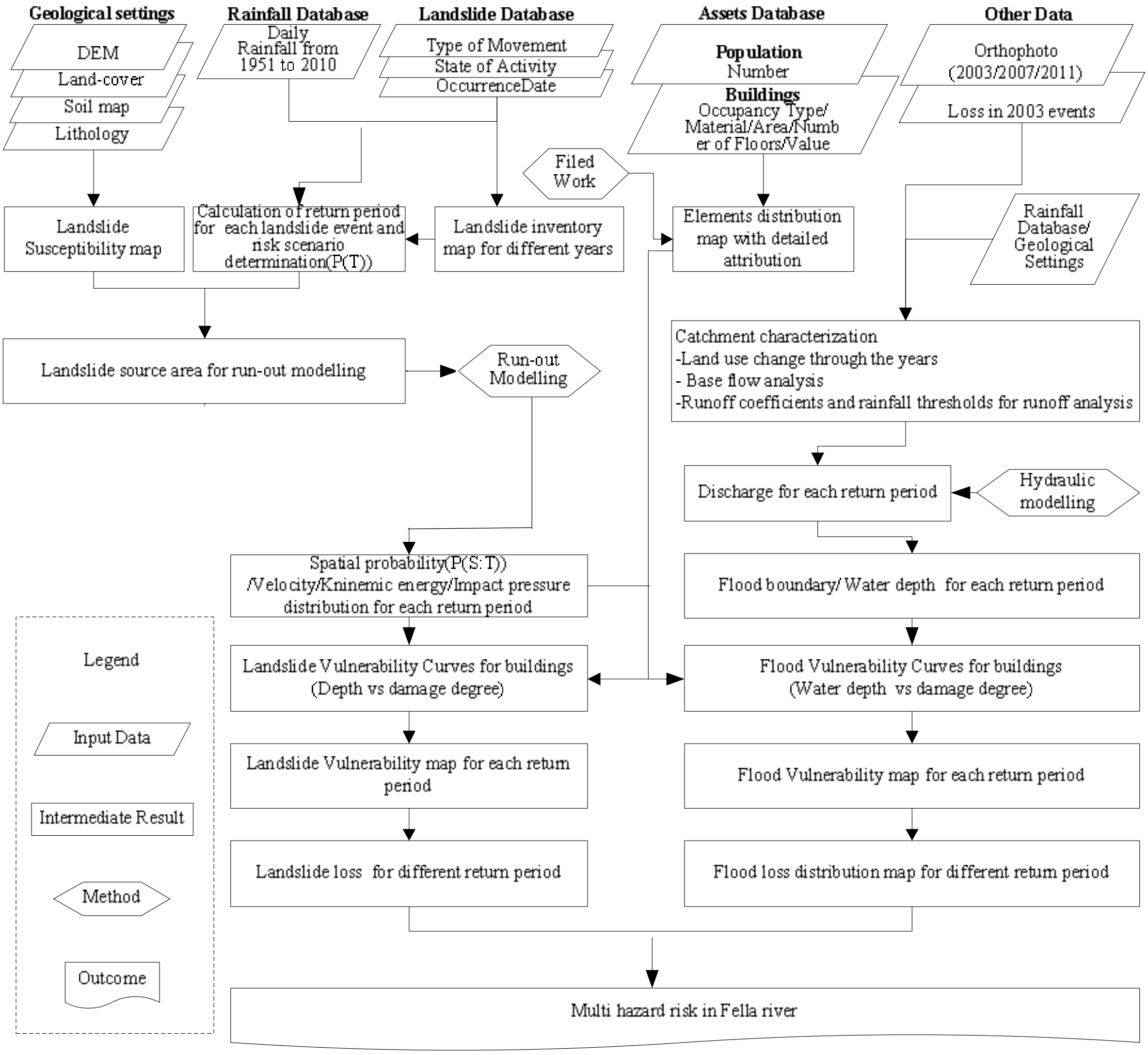


Figure 17. Methodology for multi-hazard risk assessment (adapted from Chen et al. (2014))

The highest success rates were obtained when sampling the Romanian shallow landslides as 50m grid-points and the Italian debris flow scarps as polygons. Prediction rates were highest when using the entire scarp polygon method for both landslide types. A sample size of 104 debris flow scarps were sufficient to predict the remaining 941 debris flows in the Fella River Basin, while 161 shallow landslides was the minimum required number to predict the remaining 1451 scarps in the Buzau County. Below these landslide sample thresholds, model performance was too low. However, using more landslides then the threshold produced a “plateau effect” with little to no increase in the model performance rates. We further found that several of the landslide susceptibility maps produced with different strategies and sample sizes had similar model performance rates but produced spatially different maps.

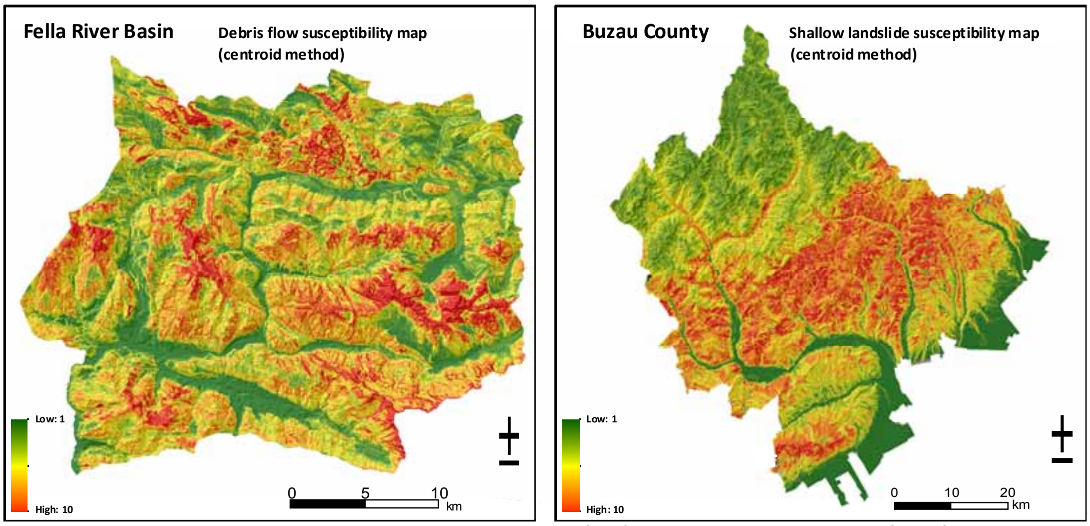


Figure 18. The best performing landslide susceptibility maps of (left) the Fella River Basin and (right) the Buzau County. The susceptibility indicates the most likely areas prone to landslide triggering and is classified in 10 classes from low (1) to high (10) (Hussin et al., 2015a).

Debris flow run-out modeling on a medium to regional scale

The debris flow run-out modeling was carried out using Flow-R, a modeling software that uses a GIS empirical distribution model to probabilistically estimate the flow path and run-out extent of gravitational mass movements at regional scales. This was done in two steps. First a set of criteria were used to identify the source areas to trigger the debris flows. The criteria were strictly developed for the Fella River Basin using only the very high susceptibility zones, the inventory of debris flow source locations and DEM derived slope and curvature thresholds . Then a set of parameters ere back calibrated for past events associated with different risk scenarios (return periods).

A quantitative risk assessment requires hazard intensities to be modeled in the form of flow heights, impact pressures or velocities. Flow-R only produced a relative probability of a debris flow reaching a certain area. For this reason, Flow-R probabilities were classified into 10 quantile classes and converted to debris flow heights using an equation relating five back calibrated FLO-2D debris flow models of past events (2003 event) to the Flow-R classes on a pixel by pixel bases. The modeled debris flow heights of three different return periods are shown in Figure 7. This area is the middle section of the valley where many debris flows had caused damages in the major event of August 2003.

Exposure and risk

The direct input maps for the exposure analysis consist of the flood depth maps for 4 different return periods (3-5 years, 40-50 years, 300-400 years, and 400-700 years), the debris flow run-out maps for 4 different return periods (1-10 years, 10-25 years, 25-100 years and 100-500 years), and the building map. The maximum intensity for each return period and hazard type for each building was analyzed in GIS. Summary information on the number of exposed buildings for different communes and hazards were generated. The risk was represented by loss curves plotting losses against annual probability.

Figure 13 shows the exposure of buildings to debris flow and floods in a small section of the Fella River area and indicates that most of the buildings are exposed to debris flow hazard. There is a general tendency that low probability event causes high exposure or risk for both flooding and debris flows. However, there are significant differences in the loss estimation between the two hazards. Table 3 represents the loss estimation for both hazards and all risk scenarios. Debris flows show significantly higher losses in all scenarios, except for the moderate scenario, where flood losses are slightly higher. The table further shows the absolute error uncertainty in both economic losses and estimated deaths, but also in the return period estimation. The uncertainty is higher for debris flow losses, which is mainly related in uncertainty in the vulnerability curves, followed by the population data.

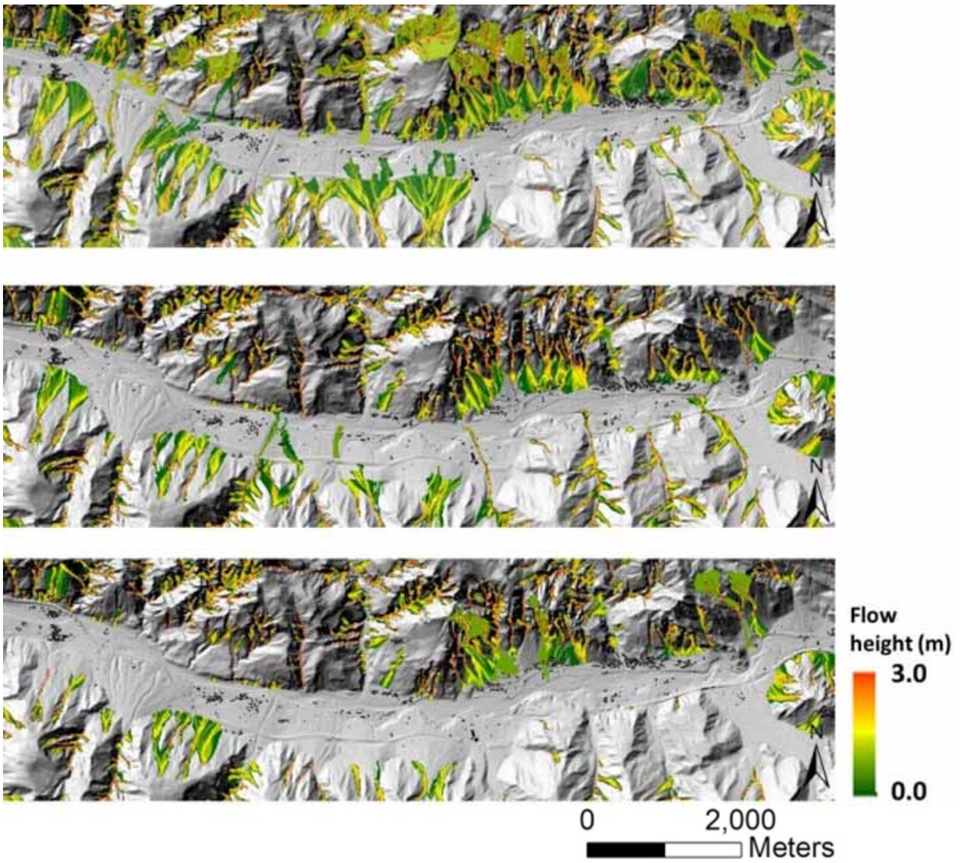


Figure 19. Debris flow height maps modeled for three risk scenarios: (above) major, (middle) moderate and (bellow) minor event (Hussin et al., 2014a).

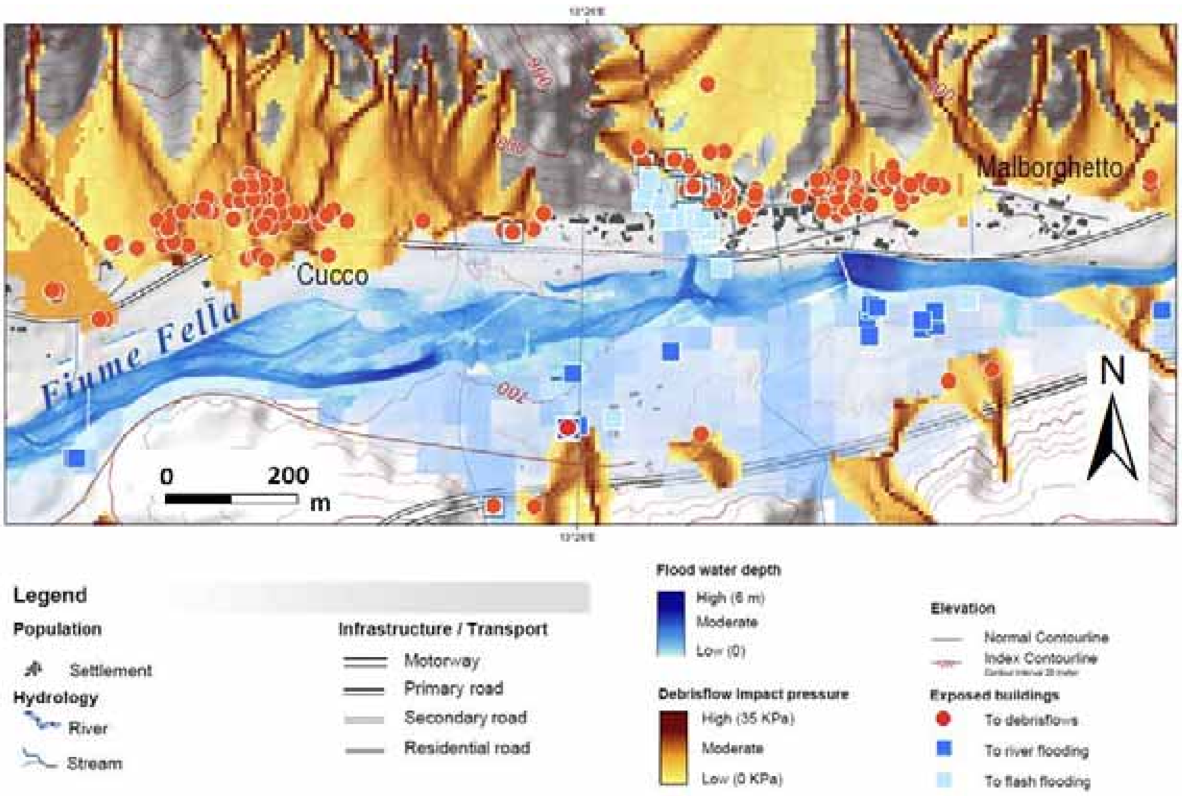


Figure 20 Buildings exposed to modeled debris flow impact pressures and flood height at the Cucco and Malborghetto villages in the Val Canale valley (Fella River Basin) (adapted from Chen et al. (2014))

Local scale debris flow modeling for residual risk assessment

The Abitato Cucco (Cucco village) side catchment of the Fella River valley witnessed a catastrophic debris flow event in August 2003. Approximately 10.000 m^3 of debris was mobilized, breaching an existing dam and destroying several structures. Thirteen houses were affected by deposit heights exceeding 2 to 3 m (Figure 15 left). The Civil Protection built new mitigation measures to protect the village, relocating two houses in the process (Figure 15 right).

Figure 21. (Left) The August 2003 debris flow at the Abitato Cucco and (right) the mitigations built after the event (Hussin et al., 2014b).

The effectiveness of mitigation measures have to be assessed in order to analyze whether there is residual risk to the village if a similar debris flow would occur in the future. This was done using a 2D dynamic numerical run-out model. The MassMov2D model running under the PCRaster language was chosen because of its open-source environment, fast simulation times and batch-file capabilities. Before predictive run-out modeling can be carried out, a back calibration is required to confine the parameters to a set of realistic values related to the specific debris flow being assessed. Figure 16 presents the results of the back analysis.

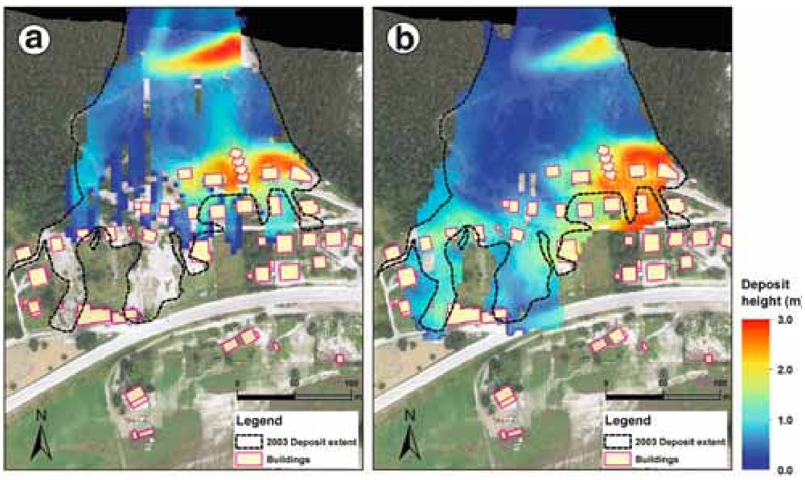


Figure 22. Back-analysis in 5m resolution of the August 2003 event: (a) model with the best estimation of deposit heights and (b) the best performing model in terms of run-out extent (Hussin et al., 2014b).

4.2.2 Summary of outcomes

- Debris flows are one of the most common and by far the most destructive type of landslides in the Fella River Basin (Eastern Italian Alps).
- The widely used Weights-of-Evidence (WofE) landslide susceptibility model is flexible and applicable to different landslide types in very different areas and geo-environmental settings.

The WofE model performs best when using the entire landslide polygon, but is not a necessary requirement for sufficient results. The WofE model requires a minimum number of training landslides (threshold) to perform well and predict other landslides at a sufficient level. Using more landslides above this threshold did not produce significant improvements. This could indicate that it is not necessary to have a very complete landslide inventory to produce good prediction models.

- By comparing an empirical regional scale model with a physically based local model, landslide hazard intensities could be estimated for large areas, which is a useful and much needed tool for quantitative risk assessment (QRA) at regional scales.

- A multi-disciplinary group of experts are required to carry out a detailed quantitative multi-hazard risk assessment.

- Landslide risk is estimated to be three times higher than flood risk in the Fella River Basin. Economic risk to debris flows was slightly underestimated while the loss of human life was overestimated in the analysis.

- In mountainous areas, where winter tourism plays an important economic role, risk assessment should take into account the touristic seasons, which is part of the uncertainty in estimating possible loss of life due to natural hazards.

- The uncertainty in landslide risk was higher than flood risk, making it a more complicated hazard to assess. Uncertainties need to be expressed in a QRA in order to understand how they are propagated into the loss estimation. The more components of a QRA that are assessed quantitatively, the more uncertainties are included and need to be expressed.

- Landslide run-out modeling can be a useful tool to predict future debris flow risk and to assess the effectiveness of mitigation measures by estimating the residual risk to people and infrastructure.

- Prediction of landslide run-out requires a good back analysis to estimate the best parameter range that can be used in the prediction modeling process. A single deterministic scenario is not sufficient for a quantitative risk assessment, but a set of probabilistic scenarios are recommended.

- At local scale, higher resolution data plays a crucial role in accurately estimating multi-hazard risk, especially when mitigation and engineering measures are implemented.

4.2.3 Challenges and follow up work

- Incomplete or inaccurate datasets when combining data from multiple sources have been a challenge in our work, and must be taken into consideration or at least acknowledged when assessing uncertainty in multi-hazard risk assessment.

- Despite landslide susceptibility maps performing equally well in terms of prediction, they can spatially look very different after classifying them using the same method. An assessment is needed to determine where different maps spatially agree with one another and how they can be combined for further risk analysis and decision making.

- Assigning landslide hazard intensities to a regional scale empirical model is a new and innovate approach because it quickly produces quantitative information for larger areas with reasonably good results. However, this requires averaging out values for larger areas and making some assumptions which naturally has led to uncertainties. Therefore, it is required to do more validation work and to quantify these uncertainties.

- We were not able to model the physical interaction and effect of the multiple hazards with one another that occurred simultaneously in our study area. In the future, this would require more data specifically aimed at hazard interactions and investigating historic events where interactions have taken place in order to at least create a database of such events.

- Other approaches for multi-hazard risk should be investigated in the future like Bayesian event trees, where a quantitative approach can still be accomplished by combining the methodology with expert based judgment.

- Some hazards require more or better data than others to model. This needs to be assessed when comparing the risk and loss estimation from different hazards.

- Each risk component (e.g. temporal probability, hazard assessment, vulnerability, value and number of elements at risk, etc.) has had uncertainties and we were able to quantify many of them. However, we still need to answer the question: which risk components cause the highest uncertainty in the loss estimation. This requires the normalization of uncertainties of the risk components and a thorough sensitivity analysis on the effect of each uncertainty on the loss estimation.

- The local scale landslide hazard modeling will be followed by a quantitative risk assessment, which also requires the combination of the different scenarios into a spatial probabilistic map to indicate the most likely areas that could be affected by a future debris flow event. Presenting many scenarios to a decision maker, without indicating which one is most likely to occur, can be confusing.

4.2.4 Personal benefits of the Marie Curie Initial Training Network

I think the best way to describe being part of the CHANGES ITN-Network, is that it was a “humbling” experience. This was not only due to the very interesting and varied PhD research topic I had, but also due to the many experts I have had the honor to work and meet with on a professional and personal level. Some of these experts are world leading in their field of research and are also extremely valuable teachers. The network gave me the very fortunate opportunity to start at the same time with a group of PhD students to work towards a common scientific goal. The collaboration with the supervisors and ESRs was really amazing and opened my eyes to a whole range of topics, expertise and specializations I was not aware of before starting the PhD journey. Living and working in Italy was also an incredible cultural experience that will stay with me for the rest of my life. Many thanks and appreciation go to my supervisors Dr. Paola Reichenbach and Dr. Cees van Westen for all their support and help throughout my PhD studies. I would also like to thank Dr. Cees van Westen for the incredible effort and dedication in coordinating the CHANGES network.

4.3 Task 3-2A : Design of a tool for probabilistic risk assessment of hydro-meteorological hazards : Designing a data model and implementing a data input module

Final Report ESR 13: Vera Andrejchenko

4.3.1 Main Achievements

Designing a data model and implementing a data input module that are able to handle hazard intensity, spatial probability data (rasters) and element at risk (buildings, land parcels, linear features etc. vectors), have sufficient flexibility to support adding user-defined hazard types (floods, snow avalanches, debris flows, etc.), hazard intensity types, intensity maps of different return periods, economic and population vulnerability information dependent on the hazard type and the type of the element at risk, in the form of vulnerability curves, user-defined vulnerability types and subtypes and relate these with structures for loss, risk, cost-benefit analysis (CBA) and multi-criteria evaluation (MCE). Having all these structures in one model enables further computations concerning loss, risk, CBA and MCE analysis of the original uploaded maps and visualization of the end results. The result from our data model looks like the figure below:

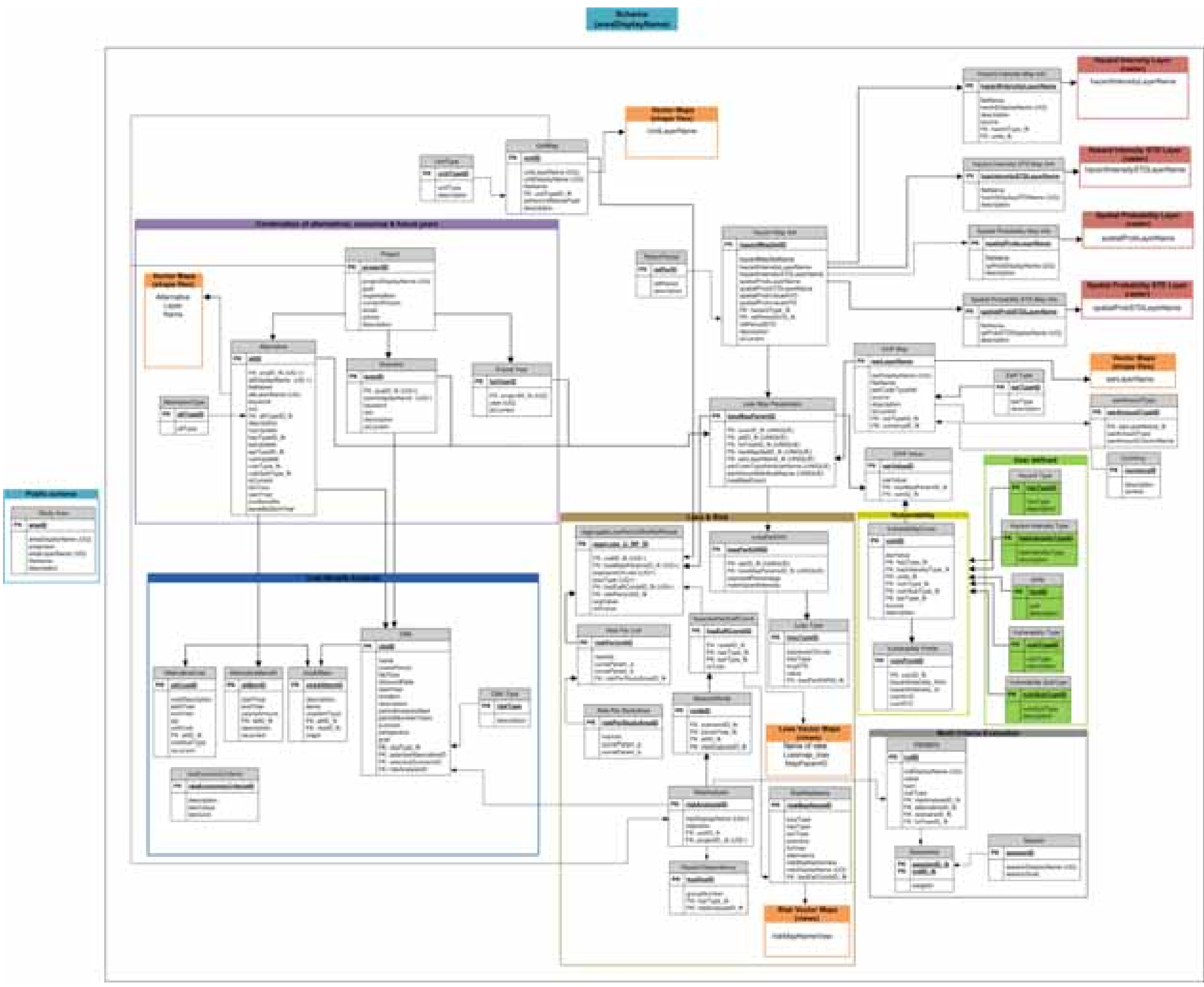


Figure 23: Data model for the SDSS.

Comparable systems are able to store or process only parts of the data. In our case we managed to embed all parts in one system, starting from the data model structures for storing user uploaded attribute and spatial data, structures for storing the calculated losses, analysis records from the risk, CBA and MCE and visualize the results. In order to be able to input and store all spatial layers, together with their attribute data from multiple study areas, we developed a mechanism which allows this data to coexist in one database as it can be seen in the figure below.

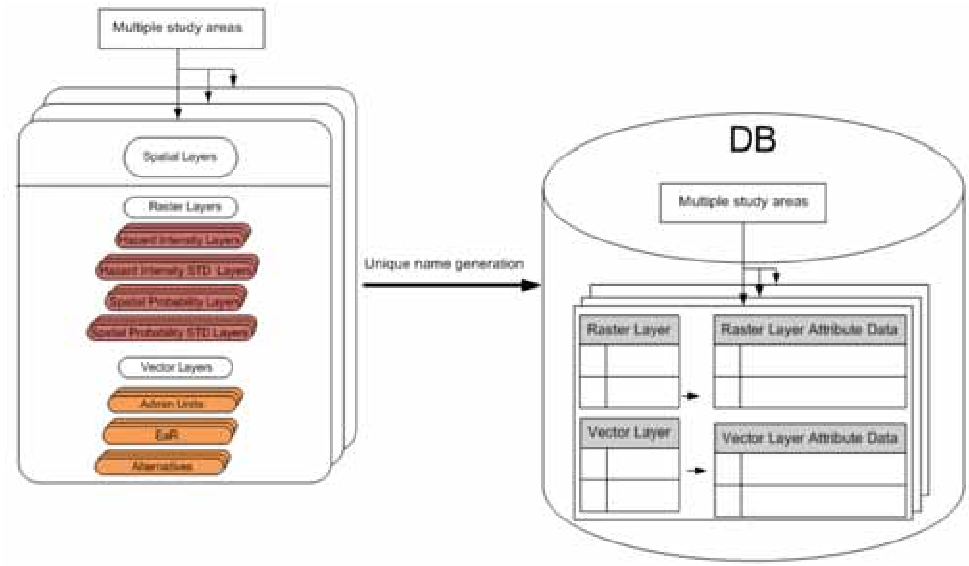


Figure 24. Database structure

Where all spatial data being in different formats as rasters, vectors and attribute information are interconnected. The developed backend system was leveraged from the front end user interfaces in order to be able to input the desired user data and see at the end the results of our functional system.

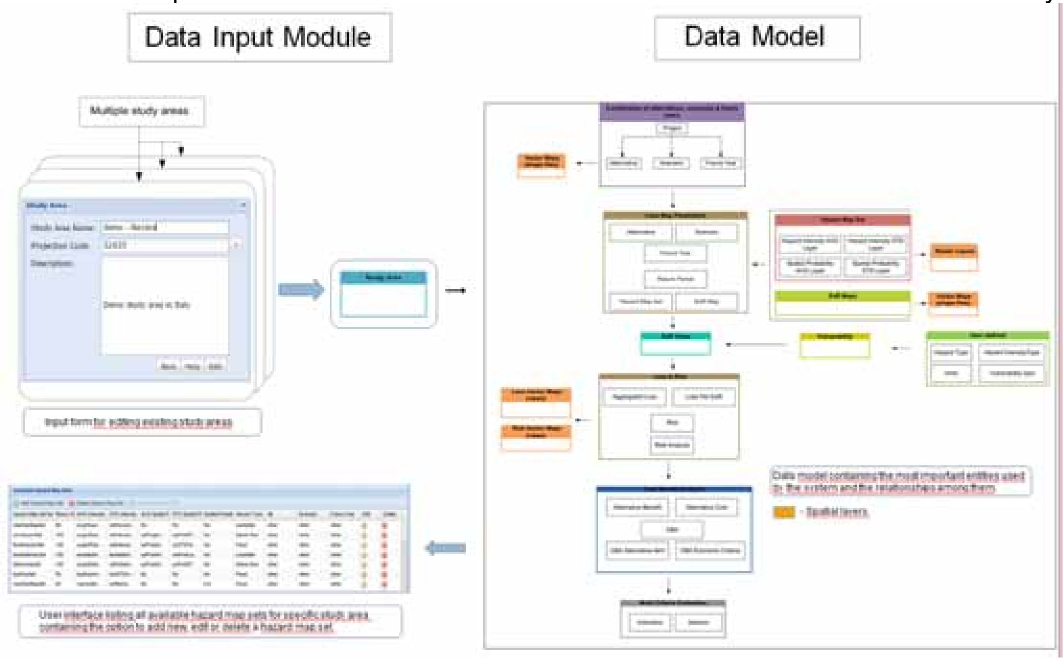


Figure 24: Input data module.

4.3.2 Main challenges

- Communication with people/scientist from different disciplines as geography, geoinformatics and computer science. Finding a common (scientific) language for communication and a common terminology understandable by all parties.
- Being distributed in different countries and universities.

But all of them we managed to overcome after a certain period of working together and with some effort from all sides.

4.3.3 Benefits from being a part of Marie Curie Initial Training Network

Skills:

- Started using and learned various Open Source technologies as Github, ExtJS (javascript library), mod_python library for database access, started using Linux vastly as an Operative System, learned python as a programming language, became more proficient in working with Postgre (open source) database management system.

Training:

- Gained the experience in working in a multidisciplinary area as Geoinformatics and in working with geo scientist coming from different countries and universities.
- Visited different university which were part of the consortium where we had frequent one week coding/lab work with the team developing the Spatial Decision Support System.
- Support from the industry, from the companies also part of the consortium.
- Had an in depth training of how GIS systems work, learned about different formats of spatial data coming from different sources and how they can be used and combined in GIS systems.
- Had presentations/lectures on Spatial Support Decision systems.
- Attended conferences, from where I had the opportunity to see the latest developments from the GIS area, meet other scientist, have a discussion with them and exchange knowledge.

4.4 Task 3-2B : Design of a tool for probabilistic risk assessment of hydro-meteorological hazards : Designing a risk analysis module

<u>Final Report ESR 14: Kaixi Zhang</u>

4.4.1 Main Achievements

The main achievements I obtained is to develop the risk analysis component within the CHANGES RISK system. The risk analysis component is subdivided into two modules: loss estimation and risk analysis. The loss estimation module produces a number of loss maps based on the combinations of hazard maps and ear maps made by users, e.g. loss_building_under_flooding_20yr. 4 steps should be conducted to compute loss: firstly overlay hazard intensity layer and spatial probability layer with EaR layer, then compute intensity and spatial probability for each EaR, retrieve vulnerability value for each EaR based on the hazard type, EaR class and the intensity value the considered EaR is exposed, finally the loss computed as the product of EaR economic value (or population number), vulnerability and spatial probability. It should be highlighted that the loss estimation module can only be executed after finalizing the data Input through another component within the system. The user interfaces of this module are shown below.

Once the combobox contents in Figure 25 are filled, all the loss combinations between hazard maps and EaR maps under the selected study area, project, scenario, future year and alternative appear in a grid, as the example shown in Figure 26 above. These loss combinations are exactly the ones users made before in data input component. Take the first record in the grid for an example, it can be seen that the hazard type is 'flooding' with the intensity layer 'fl_de_020_a0' which has been imported in our database through data input component, the spatial probability layer/value '1.0' and return period '20' years, and the EaR layer name is 'building_footprints' with a column name 'type' containing building class info and a column name 'people' containing the number of people in each building. Actually each record in the grid corresponds to a loss map. A button 'Compute Loss' is for users to compute loss maps for all the records as a batch. The produced loss maps can be visualized by clicking the button 'Visualize' which is connected with another component within the system.

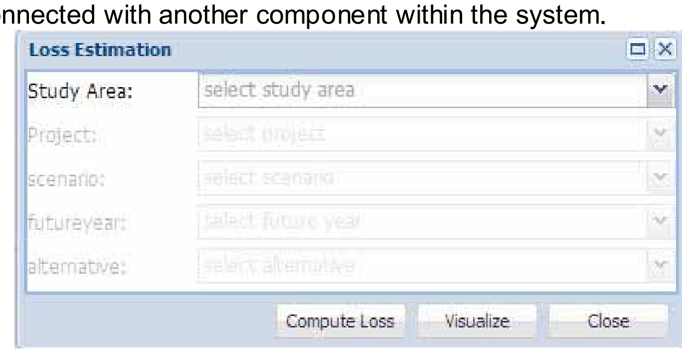


Figure 25: Loss estimation user interface

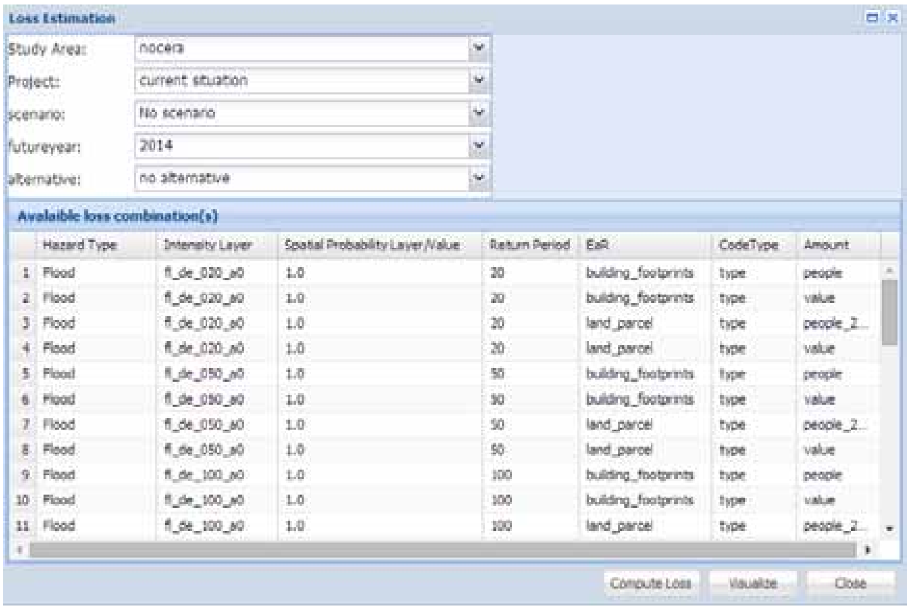


Figure 26: Loss estimation user interface after users input

The risk analysis module calculate risk using the outputs of loss estimation module. The risk can be simple (only exposure information if no return periods are available) or more quantitative. Risk analysis consists of 4 steps as well if the hazard data contains different return periods: aggregates loss values in administration units, simulate the risk curve which is exponential based, then calculate the annualized risk value, and finally the risk value and curve for the whole study area could be visualized. Users have the option to create their risk analysis for a certain purpose. Figure 27 presents the risk analysis management user interface by clicking the menu 'risk' in the main toolbar. As same as loss estimation module, users have to select the study area and the project. After those operations, the already conducted risk analysis name and unit layer adopted are displayed in the grid. Users not only have the options to edit, or delete or visualize those existed risk analysis, but also can add new risk analysis as they want. If the button 'Add Risk Analysis' is clicked, a new window (Figure 28) pop up. Users can define the name and objective of the new risk analysis in the new user interface. A unit map with polygons for which the risk is calculated should also be indicated. The unit map can be administrative units (e.g. sections of the municipality), homogenous units (user defined polygons) or for the entire municipality. The risk values and risk curves are expected to be calculated for each unit in the mapping unit layer as well as the whole study area. It should be stressed that the risk analysis name, objective and mapping unit are necessary in defining a risk analysis, otherwise users could not go to the next step. Hazard dependency is used for multiple hazards risk assessment. As shown in Figure 5, all the hazard types involved in this project have a unique group ID as default. Users are able to change the group ID of each hazard type. For example, if flooding and landslide are triggered by the same event such as rainfall, users can make these two hazard types have a same group ID. In this case, only the maximum damage caused by these two hazard types will be counted in risk computation. Instead, if two hazard types hold different group IDs, the damage caused by those hazard types are added up as a total for multiple hazards risk. If hazard dependencies are well defined, users are able to click the 'OK' buttons in Figure 28 and Figure 29 to get the next user interface risk analysis dashboard (Figure 30).

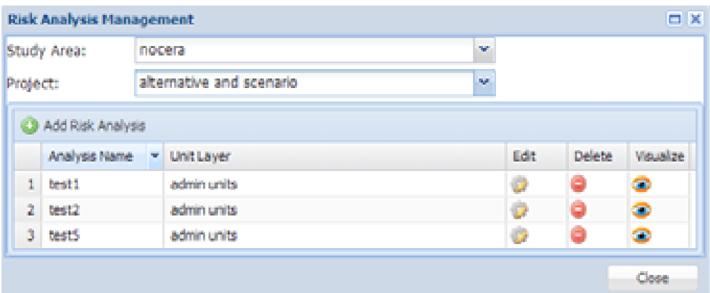


Figure 27: Risk analysis management user interface

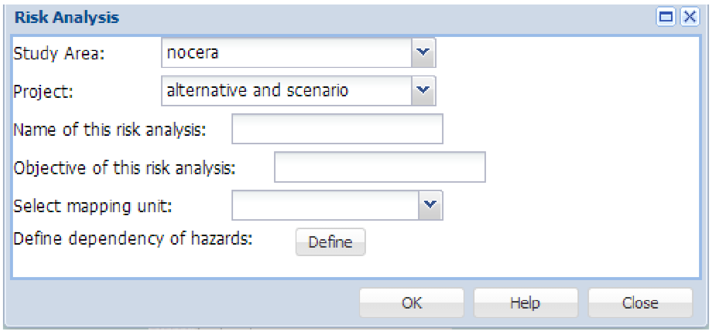


Figure 28: Create new risk analysis user interface

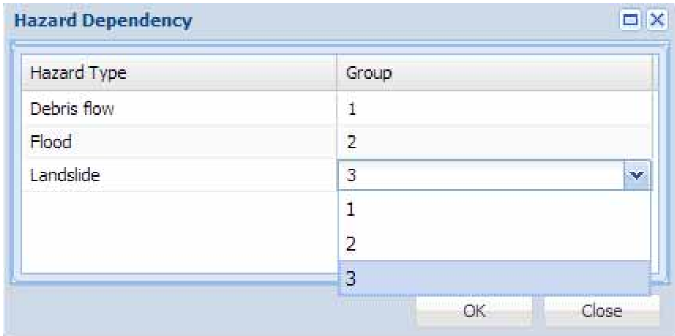


Figure 29: Define hazard dependency user interface

The risk analysis dashboard contains all the combinations of scenario, alternative and future year under the selected study area and project. As illustrated in Figure 30, each combination shown as a checkbox in the user interface. The disabled checkbox indicates that no input data, or no enough return periods available to conduct risk analysis under this combination of scenario, alternative and future year. When users tick the enabled checkbox , a pop-up window appear. Take the one shown in Figure 6 for an example, the window contains all the combination of hazard type and EaR, as well as total options. If users tick the checkbox with 'hazard' type equaling to 'Total' and 'EaR' type 'Building', it means that the risk of building under all the hazard types (flood, landslide and debris flow in this case) will be computed. The hazard dependency users defined before is used in this computation. If users tick the checkbox with 'hazard' type 'Flood' and 'EaR' type 'Total, it means that the risk of all the EaR (building and land parcel in this case) under the hazard flood will be computed. If users tick the checkbox with 'hazard' type 'Total and 'EaR' type 'Total, it means that the risk of all the EaR (building and land parcel in this case) under all the hazard types (flood, landslide and debris flow in this case) will be calculated. Users are able to tick multiple checkbox in the risk analysis dashboard and multiple combinations of hazard and EaR for each selected dashboard checkbox. Once users click the button 'Compute Risk' in the risk analysis dashboard user interface in Figure 30, all the corresponding risk curve parameters are simulated using least square method and risk values are computed.

4.4.2 Challenges

Although the fundamental implementation of the risk assessment component has nearly been finished, a lot of work such as improvements and tests are still required. Therefore, the most challenge faced is the limited time.

4.4.3 Benefits from the Marie Curie Initial Training Network

Since our teamers worked in different universities, we got the chance to travel to each university for meetings. The different academic atmosphere in different universities broadened my horizon and let me take stock of what I would like to pursue in my future career. Moreover, The opportunity to collaborate closely with my colleagues within the system development not only honed my communication skills honed, but also a pioneering spirit and the ability to do teamwork is acquired.

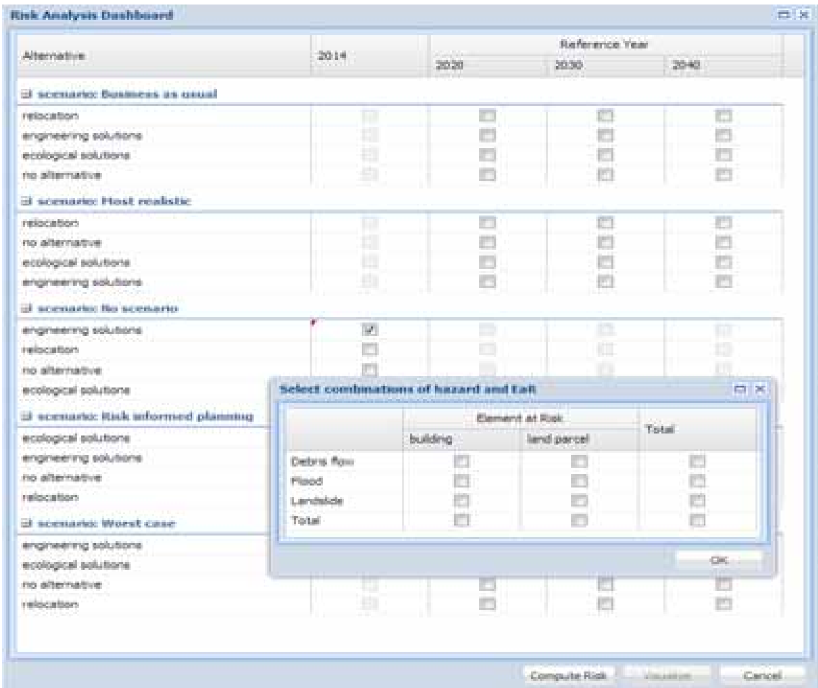


Figure 30: Risk analysis dashboard user interface

4.5 Task 3-3 : Produce risk scenarios (impacts, likelihood) and risk maps with associated uncertainties for the case study areas.

Final Report ESR 07: Veronica Zumpano

4.5.1 Main achievements

The main goal of the PhD research was to develop a method to prepare risk scenarios and maps taking into account the associate uncertainties. In order to achieve this scope Buzau County (Romania) was chosen as case study area. Landslide risk analysis and scenarios are key issues for the study area of the Curvature Carpathians and for Buzau County. With this purpose a number of landslide susceptibility maps were produced. Future scenarios for risk analysis were formulated taking into account socio-economic changes. The uncertainty associate to risk scenarios, considered land-use changes and their effects on the susceptibility-hazard-risk evaluation.

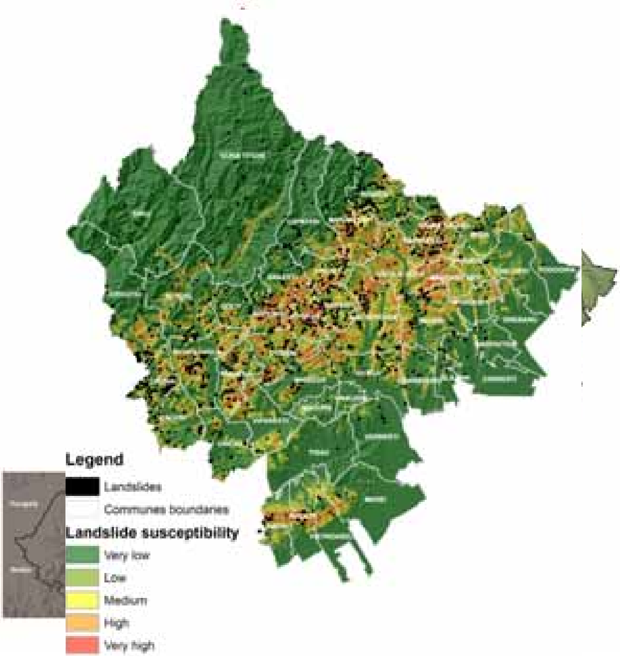


Figure 31. Romania (on the left) and on the right case study area within Buzau County

First, shallow landslide susceptibility zonation was evaluated for the entire County applying the Bayesian probability model Weight of Evidence (Fig.46).

This analysis allowed further investigations using other modelling techniques in smaller areas, with the integration of more detailed landslide database for deep-seated landslide susceptibility analysis (Fig.47). Buzau County area experienced, and is expected to experience in the future, significant anthropogenic changes, mainly affecting land-use and land management. Following this trend, a set of susceptibility scenarios were formulated in order to understand how the land-use changes will affect the spatial distribution and extent of landslides. We have considered two driving forces as main controlling factors of the land-use changes: demographic changes, mainly related to build-up areas and forest area distribution and extent.

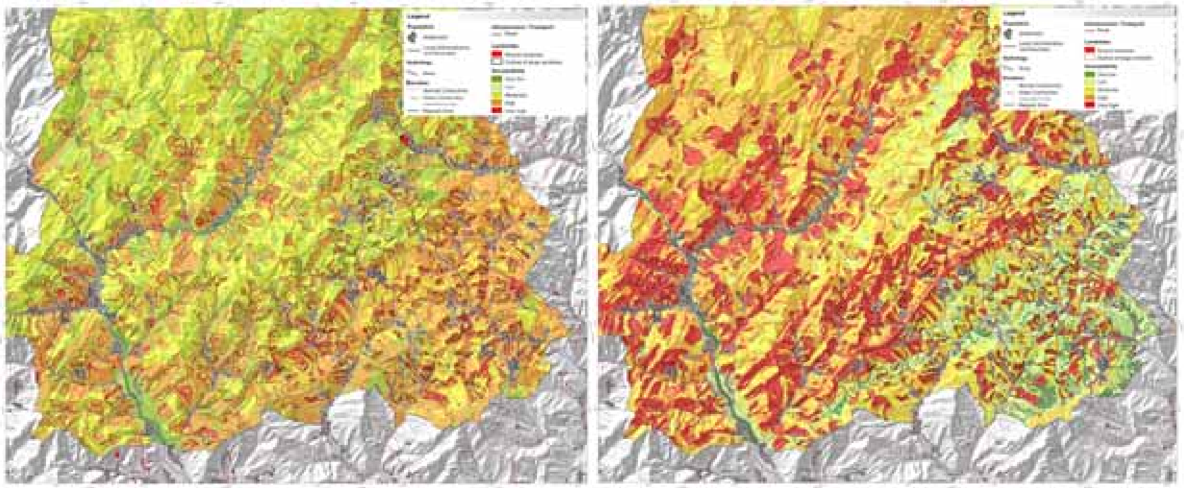
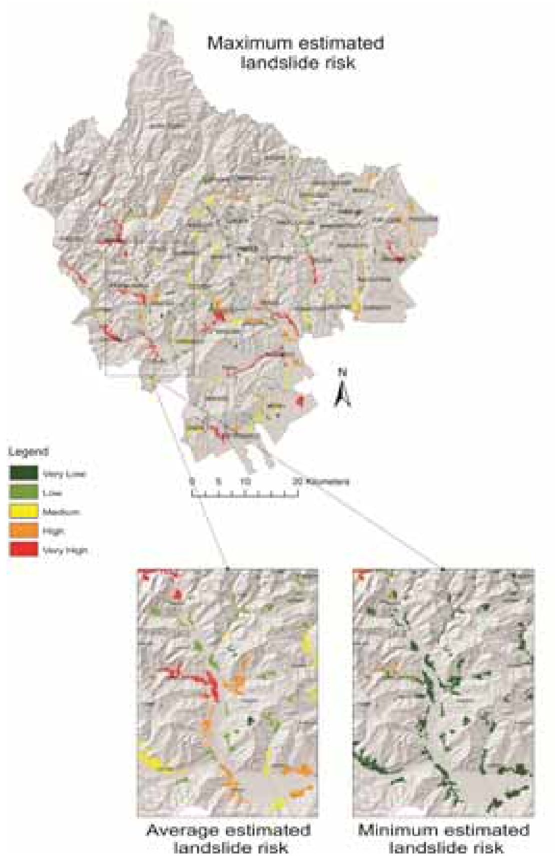


Figure 32. Shallow (left) and deep seated (right) landslide susceptibility maps (after Damen et al., 2014)

An exposure analysis was performed for the Sub-Carpathians by overlapping the susceptibility map and the build-up area obtained with the land-use changes scenarios. The exposed building area was estimated as percentage of the total area (Fig.48).

% of urban area falling in each susceptibility class	
Very low	35.00
Low	34.70
Medium	19
High	4.84
Very high	0.002

Figure 33. Maximum urban area and maximum forest change exposure scenario map (after Zumpano et al., 2014).



To complete the analysis, a local scale multi-hazard analysis was performed exploiting the occurrence of a landslide dam triggered by earthquake in the case study area, precisely in the Basca Mare area (Carpathian's area). Zooming out to the entire region, a semi-quantitative estimation of the uncertainty related to regional risk analysis was presented as a first attempt towards the understanding of the level of risk due to landslides in Buzau County (Fig.49).

Figure 34. Landslide risk map, maximum in the larger picture, average and minimum risk maps in the medallions.

Moreover a new application of an expert-based approach, useful to integrate uncertainty in susceptibility and exposure analysis, namely the Formative Scenario Analysis, was exploited. Many open questions and problems are still unsolved and need more analysis, during this research, questions and problems have been addressed for the area, and the answers can be considered as an important step towards the complete modelling of landslide risk. The landslide susceptibility maps (both shallow and deep-seated), the exposure analysis, and the regional risk analysis can be exploited by stakeholders or other researchers to understand some landslides problems, or as a starting point for further research development. The Formative Scenario Analysis approach represents an alternative approach useful for hazard and risk modelling, especially where the expert knowledge represents a fundamental source of information. The expert knowledge was used to detect the variables behaviour, where it was not possible to do detect it because of an incomplete dataset; in addition, the model includes a mathematical data processing that provides indication of the analysis uncertainty level with the introduction of fuzzy logic.

4.5.2 Abstracts

The research carried out within the PhD work, resulted in five conference proceedings and eight abstracts that have been submitted during international conferences. In addition two ISI papers (one under review) and one peer reviewed non-ISI, listed below:

ISI

- Micu, M., Jurchescu, M., Micu, D., Zarea, R., Zumpano, V. and Bălteanu, D.,(2014). A morphogenetic insight into a multi-hazard analysis: Bâsca Mare landslide dam, Landslides, 11(6), 1131–1139
- Hussin, H.Y., Zumpano, V., Reichenbach, P, Sterlacchini, S., Micu, M.,van Westen C., Bãlteanu, D., (**under review**). Landslide representation and sampling strategies in grid-based susceptibility models: review and application, Geomorphology Elsevier.

Non-ISI (peer reviewed)

- Zumpano, V., Hussin, H. Y., Reichenbach, P., Balteanu, D., Micu, M. and Sterlacchini, S.,(2014). A landslide susceptibility analysis for Buzău County, Romania, Rom. J. Geogr. Roum. Geogr., 58(1), 9–16

4.5.3 Main challenges

Uncertainty associated to risk analysis and scenarios represent a relatively new topic characterized by many unsolved questions even at international level. Developing a method to prepare risk maps and scenarios associated with uncertainties evaluation in the Buzau County represented a very difficult challenge.Often when dealing with landslide risk studies, expert users are required to consider multiple components that recall data, expertise and time. Starting from the hazard component it consists in understanding the temporal probability, in the frequency/magnitude relation. Another not less important issue is represented by the consequences component consisting in the recognition and characterization of element at risk and their vulnerability assessment. This last one represents one of the most complex issues in the risk analysis. To overcome the major challenge of the data availability many simplifications have been operated. In particular all analysis were performed the susceptibility map instead of the hazard map. The assets were not evaluated at single building level, as they were always represented by the build-up area footprint. Nevertheless this work has generated a consistent number of results, data and knowledge in the study area analysed. Further researches are still ongoing, and result improvements should be considered under the condition of comprehensive data-bases development.

4.5.4 Benefit from this Marie curie Initial Training Network

The training provided by the ITN framework was supported by numerous international scientific collaborations with other ESRs and researchers inside and outside the CHANGES network. These collaborations resulted in two ISI papers, one non-ISI (peer-reviewed) publication, five conference papers and eight abstracts proceedings that have been submitted during international conferences. During the project, 7 month of secondments have been carried out in three different institutions (CNR-IRPI Perugia, Italy; GEOMER-GmbH Heidelberg, Germany; University of Vienna, Austria) that helped the development of the research improving the quality of the final results. Furthermore, it represented an important experience in the personal and professional development, which were possible thanks to the Marie Curie Initial Training Network

5. Main results in relation to general objectives of WP4

Objectives

The main aim of WP04 is to incorporate the advanced understanding on temporal and spatial patterns of hydro-meteorological hazards and associated risks in sustainable risk management strategies, focusing on spatial planning and emergency preparedness, response and rescue activities. Starting from the findings from WP3 (ESR06 and ESR07) the optimal methodologies, instruments and tools for risk management will be designed and applied (ESR08, ESR09, ESR10, ESR11) in order to cover the whole disaster cycle, also considering the complexity of changing environments (ESR04). Then, outcomes from WP4 will be made available to ESR12 for risk communication purposes, achieved by designing specific risk visualization and communication tools.
WP04 aim were attained by exploiting appropriate methods and tools in the framework of two different temporal perspectives, concerning the changing environment: Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), land use planning (ESR08; ESR11) and cost-benefit analysis (for the construction of mitigation measures) referring to a long-term overview; early warning systems, emergency preparedness, response and rescue activities considering a short-term overview (ESR09 and ESR10).
Risk information can be integrated into EIA of future projects and SEA for spatial planning in different sectors (e.g. housing, infrastructure, agriculture, nature conservation). Land use planning tools are utilized to compare different long-term scenarios of development planning and weight the variations in the impact of hydro-meteorological hazards ad associated risks. Spatial Multi-Criteria Evaluation is an important tool in the combination of a heterogeneous set of many different factors and constraints for spatial planning. Hazard and risk information is also used as a basis for regulatory zoning plans at a local and, depending from the existing instruments, also at a regional level. What is still not fully understood is the influence of the different legal/administrative systems on the quality of risk management and transferability of best practices from one country to another. On the other side, in a short-term perspective, special emphasis in WP04 is given to the use of risk information in designing Early Warning Systems and Decision Support Systems able to provide stakeholders with effective information in disaster-related emergency (preparedness, response and rescue planning).
All partners and all ESRs within the Changes project have been involved and made aware of their role in the Risk Management cycle. In all the risk management options dealt in WP04, the changes in risk that are evaluated in the previous WP will form the basis for assessing the required changes in risk management approaches. These approaches were integrated into a Web-based platform for risk management, which can be thought as an add-on to the platform for probabilistic risk assessment (WP3) taking also into proper account the results of WP5.
Within the Changes project, strong collaboration was promoted and especially the collaboration between WP03 and WP04 (from risk assessment to risk management strategies) and between WP04 and WP05 (from risk management to risk governance strategies) is stressed. Concerning this latter collaboration, multiple meetings have been organized to discuss and fine-tune the work.

5.1 Task 4-1 : Inventory of risk management strategies in Europe focusing on land use planning and emergency preparedness.

This inventory was carried out by TUDO and CNR, with input from IRM, UNIL, R&D and AS and resulted in deliverable: D4.1 (Delivery date: M+24): Inventory of risk management strategies in Europe focusing on land use planning and emergency preparedness

5.2 Task 4-2: Use of risk information in Strategic Environmental Assessment and spatial planning

Final Report ESR 08: Kathrin Prenger-Berninkhoff

5.2.1 Main achievements

Spatial planning has to be seen as key actor for risk management, since planning comprises decisions of whether and how spaces will be used. In this context, the Strategic Environmental Assessment

(SEA) can be seen as an important tool within the planning process to promote disaster risk reduction. After all, it is not only important to assess the effects of a plan or program on the environment, but also to assess the long-term risks on the plan or program.
Risk assessments form an important basis for risk information. When aiming at reducing disasters, assessments of risks are necessary so that decision-makers and planners can be provided with an adequate evidence base to the end of guiding decision-making processes towards choosing the best options available for action.
When referring to risk-informed spatial planning it is important to take into account that respective roles of spatial planning and risk management actors vary from country to country. Each country needs to adopt its own mandatory procedures which depend on several country-specific aspects such as the administrative and legal system, the planning system and planning culture as well as the actual affectedness by and sensibility towards natural hazards. This is why this research made use of a comparative case study approach.
In concordance with the main objectives of the research, fieldwork has been completed by applying techniques of qualitative research. In this case fieldwork was mainly realised by conducting focused interviews. Main focus groups were spatial planners, sectoral planners (representatives from water authorities, geological survey and environmental protection agencies) as well as (political) decision-makers (esp. mayors) (see Table 1). The focus was on issues related to risk information used in spatial planning (type, scale, content etc.), the planning process itself (instruments, planning procedure, planning levels involved etc.) as well as the respective roles of spatial planners in the different regions or countries examined.

Interviews	Italy	France	Poland
Spatial planners	2	5	3
Sectoral planners	4	4	3
Decision-makers	2	3	2
Other (scientists, civil protection etc.)	2	2	1
Total	**10**	**14**	**9**

Table 3 No. of interviews carried out per case study site and focus group

In the following some of the findings will be a summarised in the form of tables and bullet points.

Risk Information

Depending on the national (France and Poland) or regional (Italy) approach in disaster risk reduction, different types of hazard and risk maps and/or studies are prepared by sectoral planning authorities, consulting agencies or scientific entities and provided to spatial planning authorities and planners:

Italy	France	Poland
Hazard maps (PAI) for single hazards (geomorphological, hydrological, avalanche hazards) which display the hazard in four hazard classes	Risk maps (PPR) for multiple risks (multi-risk maps), illustrating 3 zones (high risk, medium risk, no risk)	Hazard maps for floods (old version prepared by the Regional Water Board)
Geomorphological hazard maps further illustrate vulnerable elements or assets at risk	Informative hazard maps (Carte Informative des Phénomènes de Crues Torrentielles et Mouvements de Terrain) for multiple hazards (ravinements, landslides, rock falls, flash floods), illustrating two zones per hazard: proven and assumed	Hazard maps for floods (new version prepared by the Central Water Board)
Geological hazard and risk maps for the municipal territory (Carta della Pericolosità e del Rischio Geologico – Studio geologico-tecnico del territorio comunale)	Flood hazard maps (Atlas des Zones Inondables), illustrating flood extent of flood events likely to reoccur	Hazard maps for landslides and for areas threatened of mass movements (prepared by the Geological Survey), illustrating four types of areas (permanently active, periodically active, non-active and landslide-endangered areas)

Table 4 Different types of hazard/risk maps in the countries studied

Planning process

Italy:

- Risk prevention is one of the main goals of spatial planning, both at regional and local scale, whereas the PAI ensures the consideration of hydrogeological hazards in spatial plans.
- At regional level the "Territorial Government Plan" PGT (Piano del Governo del Territorio) is a strategic plan with no binding regulations, but it stresses measures that should help increase the security of the territory by trying to prevent natural hazards.
- In local plans translation of hazard assessments into land-use decisions is often too simplistic, as most critical situations are merely interpreted as building restriction.
- Different local interests are already weighed up when making maps for the PAI, which is inconsistent as the weighing-up process should come later in the planning process and it deteriorates the credibility of the information. The PAI is regarded as an instrument that is very restricting, often blocking further urban development.
- The Geological report promotes better relationship between planning and hazard analysis and assessment. Often geological reports do not provide probabilities, but produce a descriptive picture of the area and its natural conditions, i.e. no sufficient enquiry about the notion of planning and simple reaction with building restrictions for an identified hazard area, without trying to define more elaborate, tailored rules.
- Risk prevention and spatial planning do not constitute a system, but land-use decisions are based on piecemeal studies and reports, prepared by different agencies and at different scales.
- During the Strategic Environmental Assessment it must be analysed whether a spatial plan has any negative effects or impacts on the risk level of the territory and whether there are verifiable effects of the interventions planned in terms of increasing the risk related to natural hazards. The SEA does, however, not consider the need to assess the long-term risks on the plan and how natural hazards may impact the plan.

France:

- Risk prevention as promulgated by the PPR has complemented a rather defensive approach followed before and clearly conforms to a sustainable and resilient approach, a main target of territorial development.
- The PPR has proven particularly useful in restricting urban development and imposing protective and adaptive measures on new constructions. However, it remains difficult to designate preventive measures for areas with existing developments/buildings.
- Integration of risks into local planning documents is in most of the cases only endured by following the provisions of the PPR, while it is mainly ignored in cases where a PPR is non-existent.
- Until today the two approaches (urban planning and risk prevention) could not be entirely aligned: The sectoral approach (PPR) is merely imposed on an integrated local planning approach (PLU) (planning at regional level does hardly exist), i.e. the PPR prevails by excluding areas at high risk from a comprehensive and overall consideration of all available information and marking them a priori as non-constructible.
  → No weighing up of different interests within the planning process (this happens earlier in the process); Risks are solely considered within a sectoral approach, rather than a systematic, integrated approach
- According to a special guide for the SEA of local planning documents prepared by DIREN Ile de France (Direction Régionale de l'Environnement), both natural and technological risks are (or should be) subject to an analysis of the initial state of the environment. Existing risks should be known as well as potential consequences of these risks and possible evolution of the hazards in the light of climate change. This knowledge should be considered during the planning process and the preparation of urban land use plans.

Poland:

- New regulations of the Water Law now ensure actual realization of preparing flood hazard and risk maps, their consideration in planning processes and implementation of their contents in spatial plans (before, elaboration and consideration of flood protection studies in planning processes was not obligatory).
- Risks resulting from any type of mass movement have to be considered in planning documents, but there is no sectoral plan whose regulations are legally binding. At the moment a countrywide

landslide hazard assessment is carried out, which will provide planners with more detailed information about landslides and landslide-endangered areas.
- Municipalities are now required to respect the floodplain borders in their spatial plans and to carry out prevention-oriented land development in flood zones. However, the existence of a flood plain is no sole reason for prohibiting development and the head of the Regional Water Management Board has the power to reverse a restraint in individual cases, provided the primary goal of flood protection is not impaired (→ individual studies will allow realising a project). This allows for an overall consideration of available information and a more integrated planning approach.
- New flood hazard maps published according to the Flood Risk Directive cover only areas identified in the Preliminary Flood Risk Assessment. These are mainly main rivers whereas many mountain rivers, where the most violent flash floods occur, are left outside new maps. For these areas only maps from former flood protection studies made in years 2005-2012 are available. However, there is no clear regulation about whether and if yes which maps are going to be legally binding in catchments not covered with Preliminary Flood Risk Assessment.
- In Poland issues such as the impact of a plan or programme on climate change or technological and natural risks should be part of the Strategic Environmental Assessment. In the Polish case study site natural risks are analysed as part of the so-called “Ekofizjografia”, a sort of analysis of the current state of environment. However, in the actual environmental report natural risks play a less prominent role. Furthermore the environmental report lacks the elaboration of reasonable alternatives. The assessment and illustration of alternatives is a key part of the SEA, but planners usually focus on working on the actual plan from the very beginning, while considering all relevant details along the planning process, thus eliminating non reasonable alternatives right away.

Responsibilities and needs of planners for implementing risk management strategies and/or measures
It is one of the many tasks of the spatial planner to coordinate different local preferences and contexts as well as stakeholder initiatives. These local preferences have to be put into a wider context of socioeconomic and biogeographical/natural processes. This means that planners have to consider different demands on available space as well as external conditions in a weighing up process. However, due to different planning cultures, the actor “planner” has different roles and responsibilities depending on the respective national system. Besides, different legal regulations and planning practices determine the specific need of planners for risk information. In the following, characteristics of responsibilities and needs will be listed.

Italy

Actual responsibilities of the planner to use, work with and transform risk information	Needs of spatial/urban planners for risk information
• Planners do not have strong competences and do not take any hazard-related decisions • Planners have to use and respect implications of the PAI, but their pre-evaluation has no validity • Actual responsibility regarding the compatibility of local spatial plans with the given hazard profile of the territory lies in the hands of professional geologists and hydrologists, that are legally obliged to provide a geological report • A certain lack of knowledge and difficulties in understanding existing hazard maps was ascribed to spatial planners by sectoral planning entities	• Little need for information about hazards, as planners do not consider themselves responsible and competent enough to take hazard-related decisions • The hazard maps of the PAI are only used for a pre-evaluation of the hazard level • Decisions about dealing with hazards are made at a different level and by different entities (sectoral planning entities) • A “translation” of hazard information does not take place, although a closer collaboration between with geologists and hydraulic engineers is regarded as beneficial, since planners are the ones who need to consider existing hazards in the first step

France

Actual responsibilities of the planner to use, work with and transform risk information	Needs of spatial/urban planners for risk information
• An existing PPR defines a priori which areas can be developed and which cannot, so that it is not primarily the responsibility of the planners to appropriately consider existing hazards, but the PPR already constitutes a restricting underlying circumstances. • In cases in which the law allows own interpretation of present information about risks (e.g. if the law says building is not allowed unless (…)), the planner needs to decide whether this condition applies or not, which may constitute a challenge, as planners have to estimate the	• Planners consider the PPR as suitable information base, because it shows which areas are constructible and which are not, predetermines development options and therefore constitutes a useful instrument. • In cases in which a PPR does not exist, planners need other information sources at an appropriate scale in order to adequately estimate the risk for the area concerned • Geological maps are also very important. Special soil studies can be helpful in cases where there is a doubt.

risk themselves. • In case a PPR does not exist, planners need to consider and integrate all other available information about hazards, this means it is their responsibility to search and collect useful and reliable information about hazards or a separate study about the actual hazard conditions of the territory needs to be made.	However, information from such surveys needs to be "translated" for the planner by the responsible consulting office so that it can be correctly applied • In general it can be said that planners need already processed information and clear instructions, ready to be applied for planning at the local planning level, since the main decisions for planning-related risk prevention are taken at the local level

Poland

Actual responsibilities of the planner to use, work with and transform risk information	Needs of spatial/urban planners for risk information
• Actual responsibilities of planners are considered high: urban planning is a discipline that is rather wide and planners need to have a certain background knowledge (of different issues and demands that exist) in order to take the right planning decisions, consider different interests and weigh them up against each other • It is also the planners responsibility to get sufficient information about risks: They need to have enough knowledge about the area and the conditions to estimate what information they need, so that they can search for and collect adequate information, e.g. information about the potential extent of floods when there is a river near the area to be developed	• Need for clear regulations about which flood hazard maps will be legally binding in areas which will not be covered by the new flood hazard maps made according to the requirements of the Flood Risk Directive • Need for specific, meaningful and clear information at the scale of the planning level that requires not much own interpretation • Need for clear, predetermined sources of information in order to avoid contradictory data and information (in case information is taken from several/different sources) • Easy access to information (preferably free of charge) to ensure consideration of all important information available

Conclusions and recommendations

Italy

- An integrated, comprehensive approach to risks is lacking.
  → Efforts should be made to establish a multi-risk approach, which combines risk prevention and spatial planning into an integrated system and consider for different response strategies. This is very important in order not to simply respond with building restrictions and to react to a status quo of the conditions of territory, but to plan structures and developments that are both resilient and sustainable and allow for a maximum fulfilment of local objectives.
- Implementation of prevention policies aiming at risk reduction needs improvement. Laws and legal regulations are good, implementation however shows weaknesses, as often regulations are ignored or not purposefully considered and applied.
- Urban planning codes should be reinforced by robust enforcement measures (through inspections or evaluations).
- An improved collaboration between sectoral planners and spatial planners could be an asset.
- Higher incentives to retrofit could support the realization of preventive measures and thus help promoting a preventive approach in already developed areas.

France

- In order to better consider risks in spatial planning documents a more integrative approach is needed, involving an overall diagnosis of the territory and weighing up all political interests and concerns.
- Monitoring and revision of specific prevention measures should continuously take place: PPRs are not necessarily updated regularly and potential improvements in the existing level of risk – or more precisely reduction of vulnerabilities – are not accounted for unless a regular revision is accomplished.
  → Procedures in place should allow for reasonable and timely revision of planning decisions in order to adjust and adapt to changing situations.
- The Strategic Environmental Assessment could serve as an ideal tool in this context. However, not all environmental assessments are carried out with the same level of precision (some better, some worse). Improvements are needed in establishing SEA as a supportive tool that is more integrated into planning. Furthermore SEA could also help secure better monitoring and evaluation.

Poland

- Smaller catchments will not officially be covered with flood hazard and risk maps (as being implicated in the new Water Law 2011), but according to representatives from the RZGW

Krakow, flood hazard maps are made for many more rivers than actually required by law.
→ As suggested by the RZGW Krakow it would be beneficial if those maps they had already prepared before the adoption of the Flood Risk Directive could be made legally binding, since all areas exposed to fast and violent (flash) floods would be adequately taken into account in the planning process

- More precise instructions or indications on how to proceed with landslide-exposed areas with already existing buildings as well as with areas potentially at risk of landslides would be an asset for planners.
- The Strategic Environmental Assessment could also be helpful in supporting risk assessments during the planning process, not only in regard to impacts of the plan on the environment, but also in regard to potential impacts of the environment on the plan – or provisions of the plan. SEA could play a supportive role when it comes to weighing up different interests and the consideration of different alternative options at an early stage of the process.

5.2.2 Main challenges

- Determining adequate interview partners due to the multitude of responsible actors and different authorities and entities in the different case study regions examined.
- In some cases a couple of people contacted were rather reluctant to be interviewed: Some were not available, non-responsive or they declined by pointing out they did not have the time or their work was not related to natural hazards. This required quite some flexibility in the choice of interview partners, since those actors desired weren't always available.
- Difficulties in translation during the field work period: It was partly difficult, time consuming and sometimes requiring high efforts to find appropriate translators and in the end the provided translation wasn't always satisfactory.
- Difficulties in scheduling and timing interviews due to last minute changes as well as difficult interview situations and locations (noises, lack of space etc.).
- Carrying out basically all interviews together with a second ESR meant there was limited time raising your own questions, since the given time (or time allowed) always had to be split into the two persons interviewing. This also required flexibility in the choice of questions that could be asked, since often not all the questions could be raised due to time constraints.

Aspects not completed:

- Dissemination in the French case study area has not been carried out. Reasons were organisational problems and lack of time (difficulty of timing all dissemination activities with all students in all four case studies within a few months).
- As a site effect, the feedback forms that were distributed to the Polish stakeholders during the dissemination in the Polish case study site are not yet distributed in France and will be sent by email instead of handing them out personally. For the Italian case study site the problem was that only 7 people attended while only 2 of them represented one of my focus group. Therefore, the other interview partners will receive the feedback form by email, too.

5.2.3 Benefits from this Marie curie Initial Training Network

I very much benefitted from the team work and the fact you had to work with and coordinate your own work and research with one or several other researchers. This common work proved to be very fruitful. It was also very beneficial to work with more experienced researchers and to be accompanied and supervised by a group of researchers that guide you and your work.
Being able to work in an international project with many project partners made it possible to expand my research network and to get to meet many different people working in the same or in similar fields of research. I benefitted from the technical skills courses in the sense that I was introduced to topics and methods I had no experience in before. Personally I was, however, more interested in the topics and contents of the soft skill courses and the workshops (which could've been allowed more time in my personal opinion).

5.3 Task 4-3: Development of a web-based decision support platform for use of risk information in risk reduction

ESR 09: Zar Chi Aye

5.3.1 Main achievements

In this research, a prototype web-based collaborative decision support platform is developed, aiming to support the engagement of different stakeholders and collaborative group decision making in selection of risk management strategies. The conceptual framework of the prototype platform is initially based on the feedback and observations obtained from field visits and stakeholder meetings carried out in the case study areas of the project: the Malopolska Voivodeship of Poland, Buzău County of Romania and Friuli-Venezia-Giulia region of Italy. Based on the needs and issues identified in each case study site, this research also explores how such a collaborative platform could potentially assist and enhance the interactions between the risk management stakeholders in formulation and selection of risk management strategies through the use of interactive web-GIS and multi-criteria evaluation (MCE) tools, particularly targeting preventative measures for floods and landslides. The background conceptual framework is illustrated in Figure 35 with its step-by-step demonstration of the main interfaces of the prototype as an example.

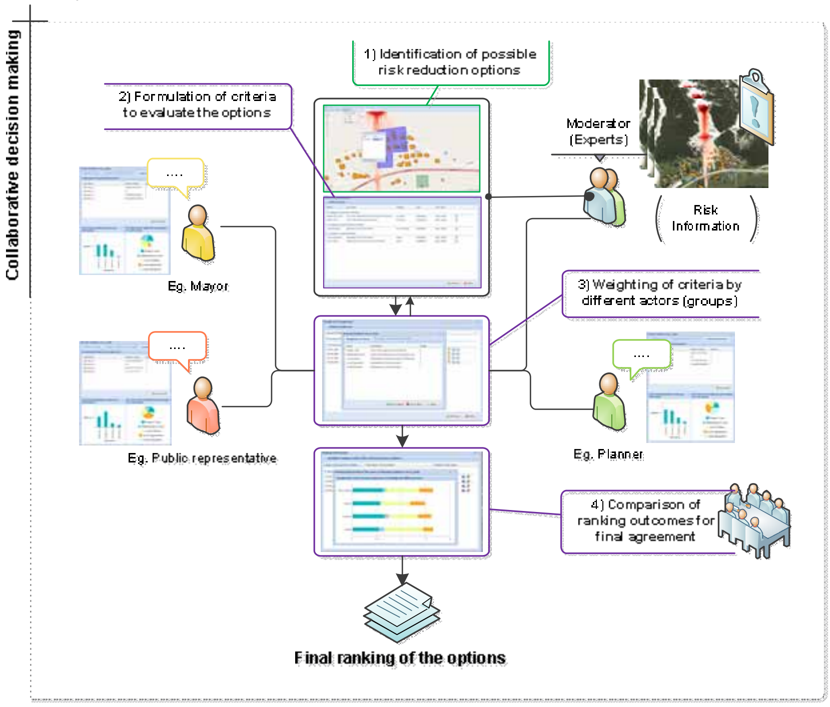


Figure 35 Collaborative decision making framework of the developed prototype platform

Figure 36 An example illustration of Step 1 and Step 2 for identification of possible risk reduction options (left) and its corresponding criteria (right) to evaluate these options in the impact matrix

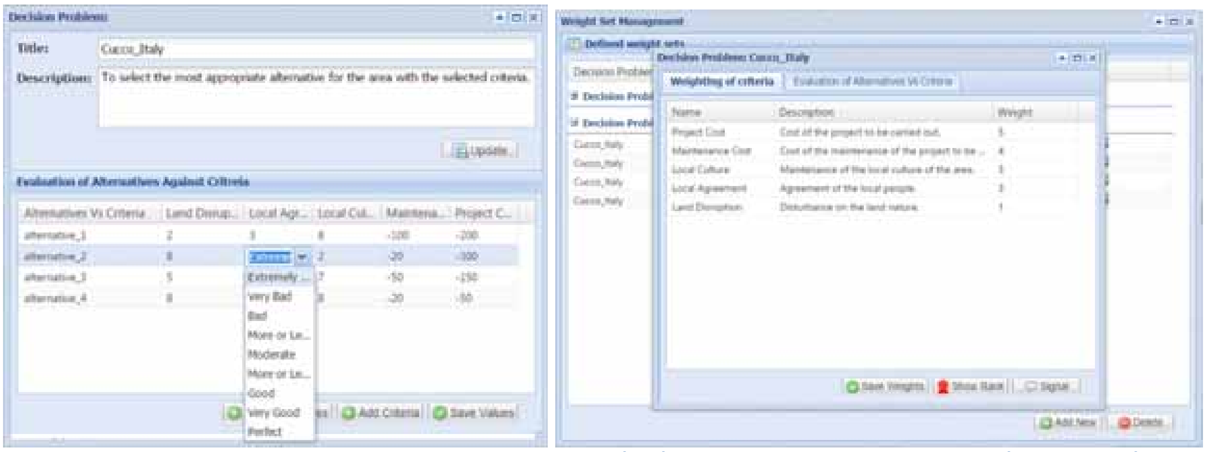


Figure 37 An example illustration of the impact matrix (left) and weighting process of criteria (Step 3, right)

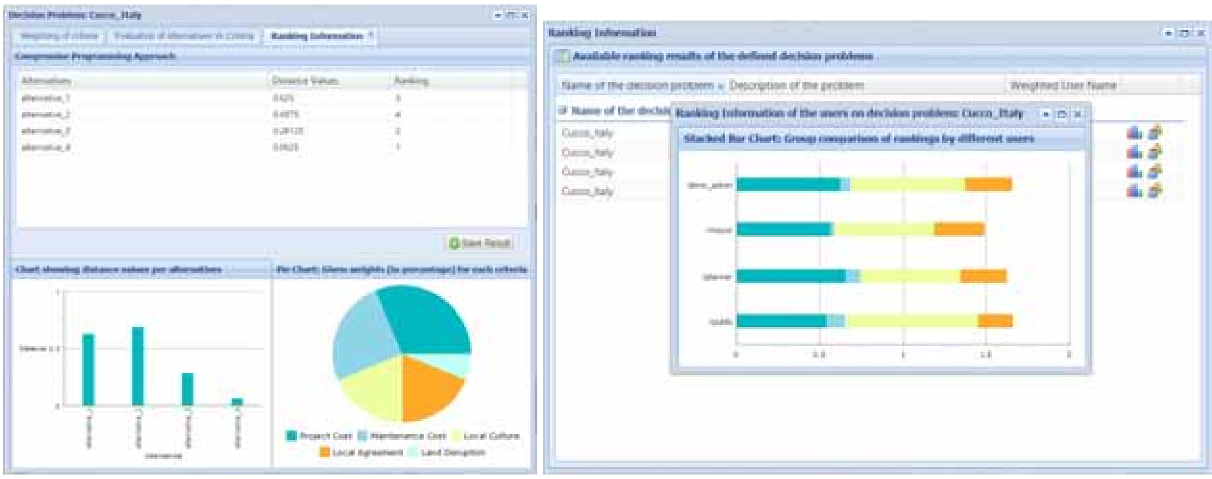


Figure 38 An example illustration of Step 4 for the visualization of own ranking results (left) in comparison with others (right)

This collaborative prototype platform was presented to the local and regional stakeholders of the mentioned case study sites to understand the stakeholders' perspectives in finding whether it is useful and applicable for their activities. One-page preliminary feedback forms were provided to the participants and a total of 49 feedback responses were received.

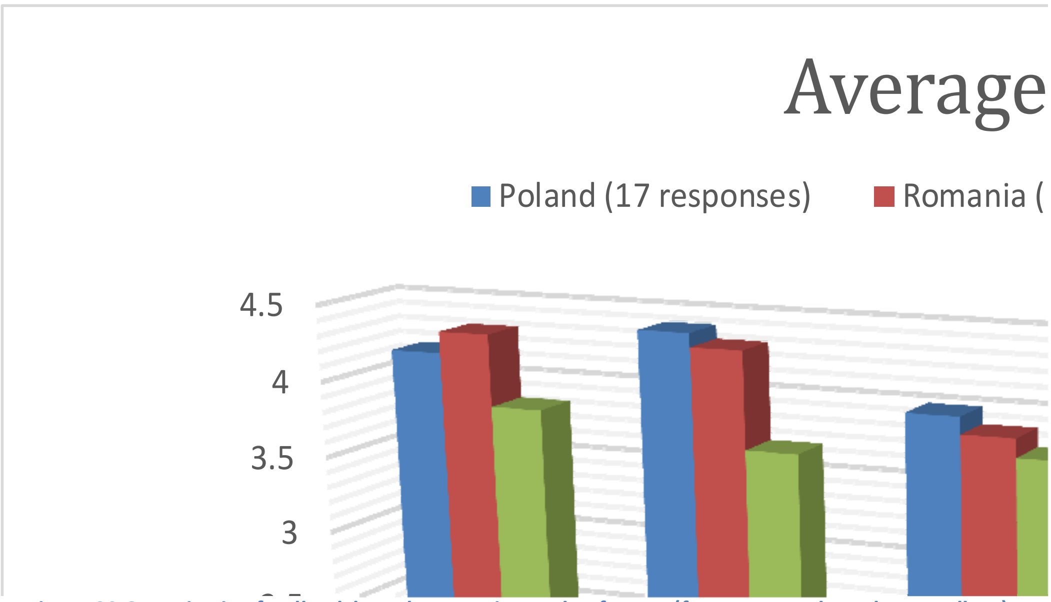


Figure 39 Quantitative feedback based on a rating scale of 1 to 5 (from Extremely Bad to Excellent)

According to the analysis result of the feedback responses, the stakeholders found the prototype useful, innovative and supportive while user friendliness and practice aspects of the platform need to be improved for the development of a full-scale system. There was a relevant concern regarding the participation of experts in the platform and that there should be a way to motivate experts to engage in the process, as stated by planning stakeholders in Poland. It has also been suggested, especially by Romanian stakeholders, to develop concrete exercises with different stakeholders to validate its functionality and to determine whether the stakeholders can interact amongst each other through the use of the platform. It was also suggested to introduce a manual and to organize instructional training courses to apply the prototype platform in practice. Last but not least, the Italian stakeholders also mentioned their interests in potential integration of cost-benefit and interactive spatial query tools to analyze the consequences of hazard events in a certain area of interest.Within the prototype platform, additional supporting components are also integrated for expert users to analyze the impacts of floods and landslides based on qualitative object-based or quantitative analysis, as demonstrated in Figure 6 and 7 respectively using the regional Fella River data set of Italian case study site produced within the project.

Figure 40 Qualitative Impact-Probability matrix to analyze the important objects for protection and prioritization in the area

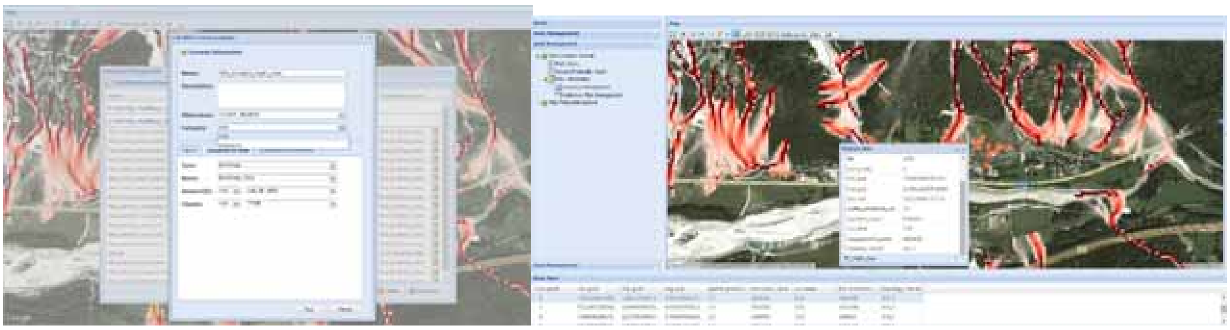


Figure 41 Loss calculation component (left) with the visualization of a calculated loss scenario (right)

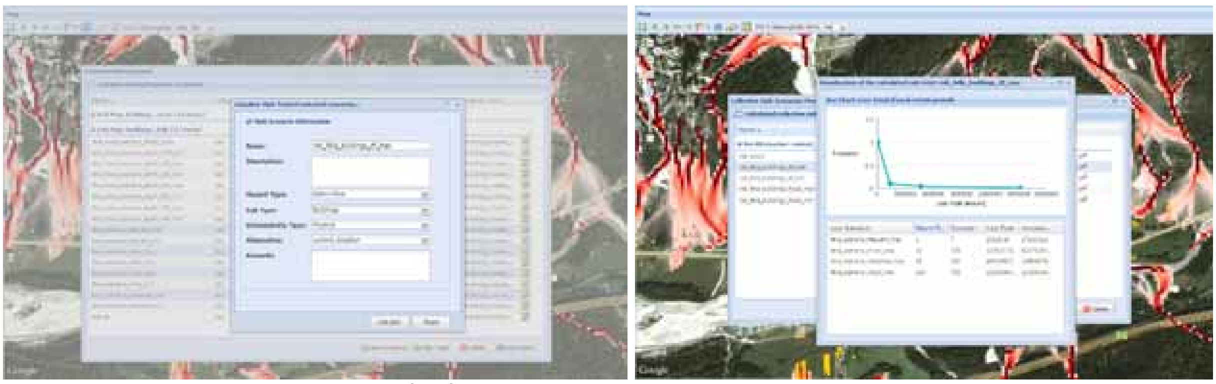


Figure 42 Risk calculation component (left) with the visualization of an annualized risk scenario with different return periods (right)

5.3.2 Main challenges

One of the main challenges could be to carry out an intensive user requirement analysis in all the case study areas of the project. It was a challenging task considering there are different stakeholders and institutional settings with varying objectives and needs on the potential development of such a platform. Instead, empirical inputs of this study were collected based on the initial feedback and observations obtained from the field visits and stakeholder meetings carried out in the study areas, focusing on the decision making process in risk prevention and mitigation. The platform, thus, was designed in a generic approach so that it can be readily applicable not only in the study areas but also in other regions, which is another challenge of this research in formulating its conceptual framework of the platform. Regarding the technical challenges in development of such an integrated decision support platform, the prototype was implemented using Boundless architecture and its client software development kit (SDK) due to its flexible, open-source architecture with built-ins and extensible components of the application development while the challenges still remain in upgrading the currently deployed libraries such as ExtJS to make use of its available latest version. Another remaining challenge, as pointed by stakeholders above, would be in engaging potential stakeholders to actively participate in collaborative decision making process, and therefore, ways to motive stakeholders would need to be further explored in order to improve the applicability of the platform.

5.3.3 Benefits from this Marie curie Initial Training Network

- Training and research in relevant fields through technical and professional skills courses, topical workshops and regular meetings, field visits and stakeholders meetings in study areas
- Secondment visits to partner institutions for collaboration and knowledge exchange activities
- Social and networking activities for close interaction with fellow ESRs within the network as well as to encounter experts and other researchers working in the same field
- Capacity building in research, language and other skills in the host and partner institutions

Availability of funding to attend external courses (including language courses), workshops and conferences for knowledge transfer and dissemination activities

5.4 Task 4-4 : Emergency preparedness and early warning scenarios based on the outcomes of the probabilistic risk assessment.

Final Report ESR 10: V.J Cortes Arevalo

5.4.1 Main achievements

Motivation, objectives and main achievements

There is an increasing interest in the use of citizen-based approaches to better understand the environment and hazard related processes. Moreover, modern approaches for risk management promote exchange of information between local authorities and volunteer groups to support preparedness and preventive actions (Enders, 2001). Such directives promote citizen involvement to build a culture of resilience before, during and after a disaster strikes (European Commission, 2012).
Hydro-meteorological events in mountain areas are often caused by multiple and sudden onset floods and debris flows. Traditionally, hazard mitigation in the European Alps is mainly organized by implementing structural measures. However, the increasing frequency and influence of flow and sediment processes also affect the functional status of hydraulic structures, and vice versa (Holub and Hübl, 2008). Opportunities in promoting citizen science projects stem from the increasing frequency, timeliness and coverage of surveillance activities (Flanaging and Metzger, 2008). Besides situations where financial and human resources are limited, scientific monitoring may be subject to additional complexity under dynamic environmental conditions or remote settings (de Jong, 2013).
In that context, this research aimed at evaluating the practical use of citizen-based information to support inspection and maintenance planning of check dams. We focused our methods on the Fella basin, Italian study area of the CHANGES Project. Such choice considered the interest of regional services and local authorities to engage citizens on inspection activities. Moreover, the strong involvement of citizens in volunteer activities of Civil Protection facilitated the engagement of participants within the research activities. Table 1 summarizes the research objectives and main achievements:

Table 5. Overview of the research

Research Objectives	Main Achievements	Journal Publ.
(1) To identify complementary data that citizens can report to support emergency preparedness and early warning strategies related to hydro-meteorological hazards.	a) Engagement of stakeholders for the identification of needs and opportunities of citizens' based data. b) Testing of an inspection form to carry out first level inspections on the functional status of check dams	1 Conference paper
(2) To evaluate data quality collected by volunteers for first-level inspection of hydraulic structures in mountain catchments.	a) Quality indicators of data collected based on the accuracy, precision and completeness. b) User requirements for a prototype web-tool to manage first level inspection reports.	1 JP
(3) To systematically evaluate first level inspection reports while getting indication on the functional status of the structures inspected.	a) Decision support method to systematically evaluate first level inspections reports. b) User-centered design of a prototype web-tool for the management of first level inspections.	2 JP under preparation
(4) Recommendations to enhance links between mitigation/prevention and preparedness activities related to hydro-meteorological hazards Objective carry out within joined research within the WP4&5		1 Co-JP 1 Co-JP under preparation

Methods and results

One important aspect of this research is the use of user-centered design approach (Figure 1). Such approach is an iterative process starting by 1) users' requirements; 2) design of procedures for data-collection with trained volunteers and technicians; 3) Design of a prototype web-based tool for quality evaluation and management of collected data. Thereby, we used methods such as stakeholder meetings, informal interviews, data-collection exercises and evaluation workshops for the design process of the inspection forms. Data collected in the inspection form accounted for questions and rating options about the condition of the structure, obstruction level and erosion.

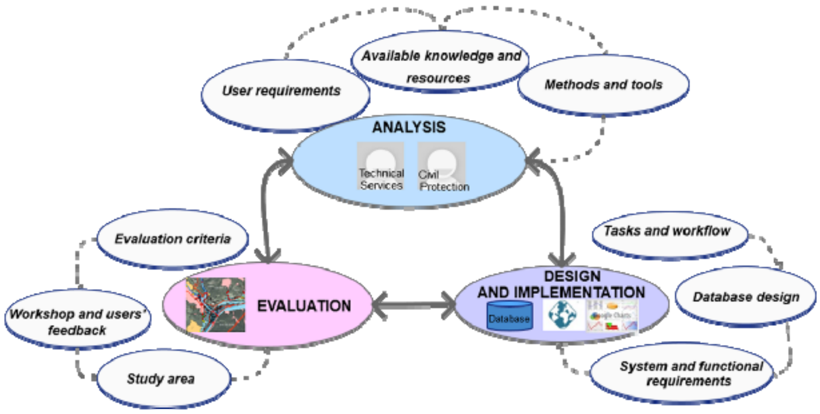


Figure 43. User centred design approach based on Baroni et al (2010).

Analysis stage:

Our aim was to identify reliable user requirements. To that end, we organized a data collection exercise in May/2013. Thereby, we evaluated the quality of data collected by 25 volunteers and 11 technicians. Volunteers accounted for citizens' volunteers of civil protection, students of geosciences and master students of social sciences. To that end, we asked all participants to inspect same structures. We evaluated data quality by comparing first level inspection reports and checking their completeness. Results at first iterative stage confirmed that data collected by volunteers had higher variance as compared to technicians. However, they can have a comparative performance by generalizing rating options at one rating level for the data evaluation (Cortes Arevalo et al., 2014). Moreover, general limitations for the comparability and reproducibility of reports applied for both volunteers and technicians. Therefore, systematic evaluation of first level inspections is still required to understand the implications of data quality into the decision outcome.

Design and implementation:

We designed a decision support methodology for the systematic evaluation of first level inspections (Figure 2). Senior technicians are representatives of the works' holder authority with competences in the management of the structures. For example, civil protection, forestry service and geological survey. The input data are ratings reported by trained volunteers or technicians for structures that have been scheduled for first level inspection. Then, senior technicians use the decision support methodology to evaluate available reports and to get indexes representing the functional status. The output is the functional status of the inspected structure into three indicator parameters: A) condition of the structure, B) level of obstruction at the structure and C) erosion level in the stream banks. Finally, senior technicians can set rules at parameter level to distinguish functional levels. The rules are based on thresholds for the calculated indexes and the worst inspected rating. Thereby, functional status is categorized into three levels.

Then, the methodology was implemented as a module of the prototype web-tool for the management of first level inspections (Figure 3). Overall, the web-based tool comprised of four modules. However, designing and prototyping focus was on the evaluation module as it determines the practical use of citizens based data.

- Registered Users: Senior technicians that available first level inspections
- Inspection plan: List of structures to inspect and report by volunteers and technicians assigned.
- Reports: Available inspection reports
- Evaluation: Implementation of the decision support methodology

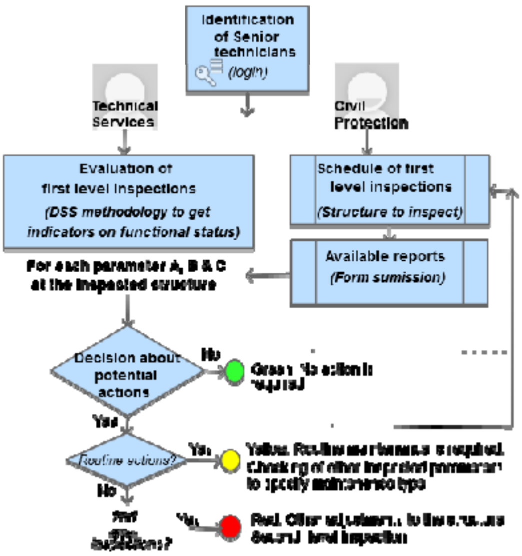


Figure 44. Flow diagram describing the evaluation process for the first level inspection

Evaluation stage:

We organized a workshop to validate the decision support methodology with potential users and to incorporate necessary feedback of new users within the iterative design of the inspection form. Therefore, 14 participants attended among technicians of the case study and neighboring regions and last-year students of geosciences.

The evaluation module was considered useful and innovative by the technicians. However, a more comprehensible and simple interface should be developed to better guide technicians. Besides the evaluation module, the other modules of the prototype tool need still to be finished. For example, the submission of inspection reports was not available for the workshop. Further research stages in the prototype tool may include outputs of this study. For example by implementing participants' feedback into the remaining functionalities of the prototype and database management system. Finally, for

volunteers a different interface needs still to be designed. The focus of such interface should be on accessing the inspections plans, carrying out the inspections in the field and submitting reports.
Overall, the practical use of citizens' data stem on understanding and handling uncertainties introduced into the decision making process due to the data quality. Limitations of visual inspections applied for both volunteer and technicians. Despites of the inspector, data should be systematically evaluated before using it into the management organization. Risk managers are willing to consider volunteers' inspections only to pre-screen potential problems that may require preventive maintenance. Findings highlight the importance of a culture of volunteer activities and the role of institutional frameworks in supporting volunteers' involvement. Finally, inspection guidelines should support completeness and precision of volunteers' reports. Training strategies should also account for providing feedback to participants about the data-quality collected after every inspection campaign.

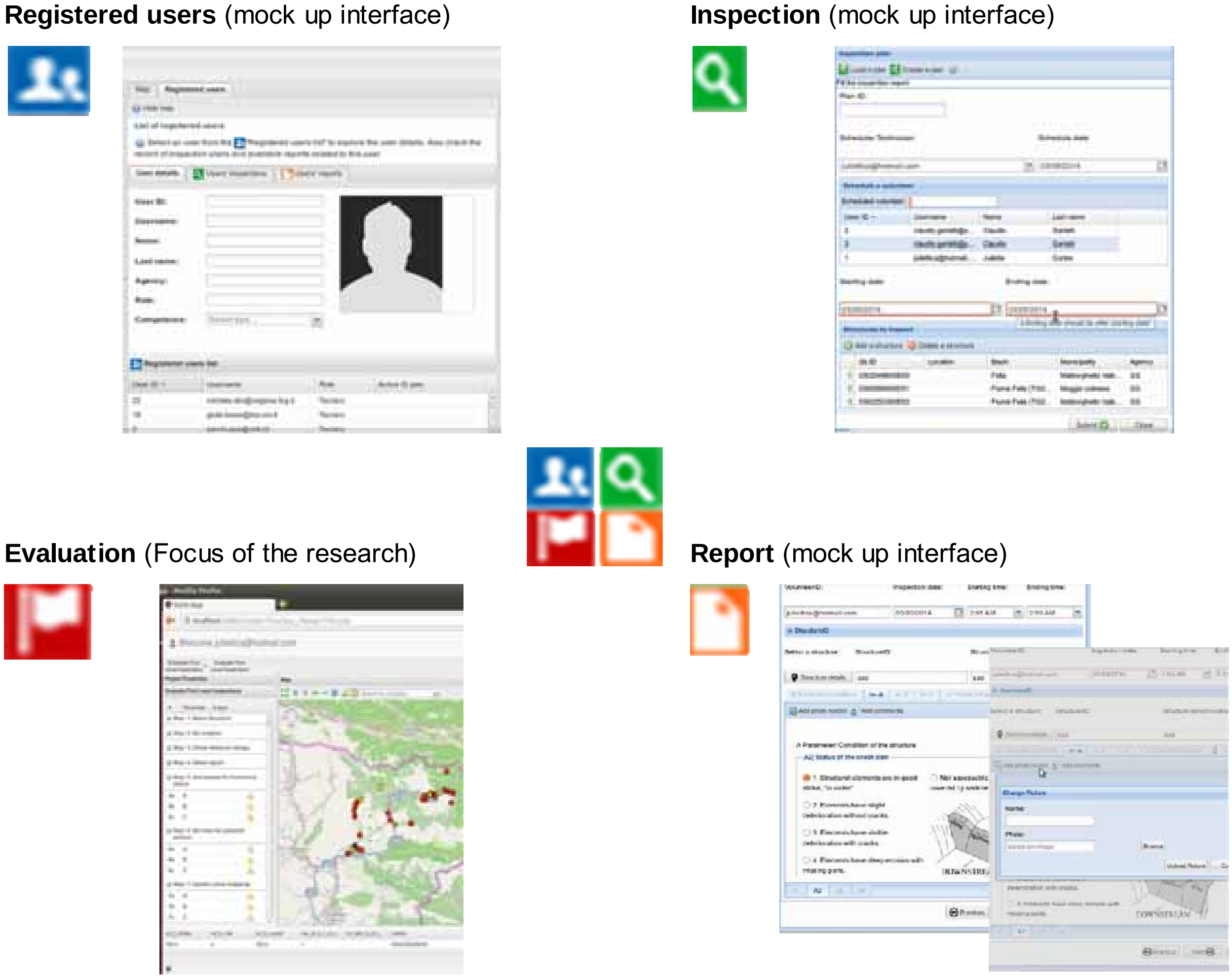


Figure 45. Prototype web-tool for the management of first level inspections

5.4.2 Main challenges

- **Validation of methods in other study sites:** The research addressed two dimensions. Those are the methodological aspects, the practical aspects of ICT tools and stakeholders' collaboration. Research methods accounted for stakeholders meetings, data collection exercises and workshops with stakeholders involved. However, collaborative research approaches are in general time consuming and require speaking the language of the study site. In Italy, I had collaboration of stakeholders and supervisors to carry out the research in the Italian study site. In other study areas, it was not possible to validate the methods due to time constraints and language.

- **Development and implementation stages of the web-based tools:** Focus of this research was on setting functionalities to use first level inspections. We managed to set up a workshop to test the most important module for the research. Implementation stages may still benefit from the contribution of software and mobile application designers. Such interaction is particularly important to facilitate the testing of prototype tools with final users.

5.4.3 Benefits of Marie – Curie Training Network

- **An opportunity to enhance organizational and communicational skills:** For my PhD, I was in Marie Curie Training Network while researching in close collaboration between the TUDelft and the National Research Institute (CNR-IRPI, Padova and CNR-IDPA, Milano). The Marie Curie Training network has been a real-life school to enhance organizational and communication skills, which are very important skills for a researcher. On one side, the PhD approach was a learning experience to translate science into simple terms. On the other side, the interaction within the network allowed me to be aware of risk management practices in other study areas and to interact with other ESRs colleagues.

- **Different perspectives of the research topic:** The diverse but complementary background of my supervisors was very useful for guiding me into the different aspects of the research. Moreover, the involvement and interest of Civil Protection was a key aspect for the user centered design approach. I consider that partnerships between practitioners and researchers are important to bridge the gap between the requirements of science and real-life management practices.

- **An opportunity for knowledge exchange:** Having the opportunity to meet and interact with my ESR colleagues was a key aspect to address different challenges of my research. For example, I tested my methods mainly on one study area. However, I became aware and contribute for the management requirements in other study areas by working jointly with my colleagues in the WP. I was also able to learn about software developing tools by interacting with my ICT colleagues.

- **Wider vision on research methods and risk management practices:** Being in the different workshops of the project was sometimes time consuming and implied moving a lot. However, I have understood that there are different possibilities to adapt examples of good practices to local actors and resources. I have also found value on having a parallel perspective of different risk management practices, research methods and study areas.

5.5 Task 4-5 A : Design of a tool for probabilistic risk assessment of hydro-meteorological hazards : Designing a cost-benefit analysis module

<u>Final Report ESR 15: Julian Berlin</u>

5.5.1 Main achievements

The Risk-CHANGES platform is web-based Spatial Decision Support System (SDSS) in development for the CHANGES group, part of the EU FP7 Initiative funded by the Marie Curie training network. The aim of the platform is to allow users from government organizations or NGO groups to conduct probabilistic multi-hazard risk assessment taking into account changes in natural hazards, scenarios related to climate change and population change and exposed elements at risk with the idea of evaluate optimal risk reduction alternatives. The following figure illustrated a possible workflow to use the web-tool.

Within this project one of the main achievements was the implementation of a financial Cost & Benefit method method. Only monetary losses are taken into account, the main benefits are the avoided monetary losses by the implementation of a risk reduction alternative. To estimate the benefits we need the annualized average losses (AAL) for both, the situation without risk mitigation and the AAL for the situation in which we have risk mitigation in place (a risk reduction alternative implemented and these values are loaded directly from the risk module. This module is fully integrated with the risk estimation module and the MCDM module.

In the current implementation users can define the costs for the defined risk reduction alternatives (RRA) for a given project and also add additional benefits/negative benefits in the analysis, also user has the option of choosing the proper AAL values from the risk module to get an overall estimation of the yearly benefits and the problem of discounting these future values using an user defined interest rate is contemplated. Figure 32 gives an example of the user interface of the cost-benefit module. The cost-benefit analysis for alternatives in combination with possible future scenarios uses the calculated risk for future years, and will therefore also change the risk reduction for these years. For intermediate years the data is interpolated. This allows users to take future changes into account in a cost-benefit analysis, instead of keeping the risk reduction constant for the entire project lifetime, as would be the case when we would only look at the current situation

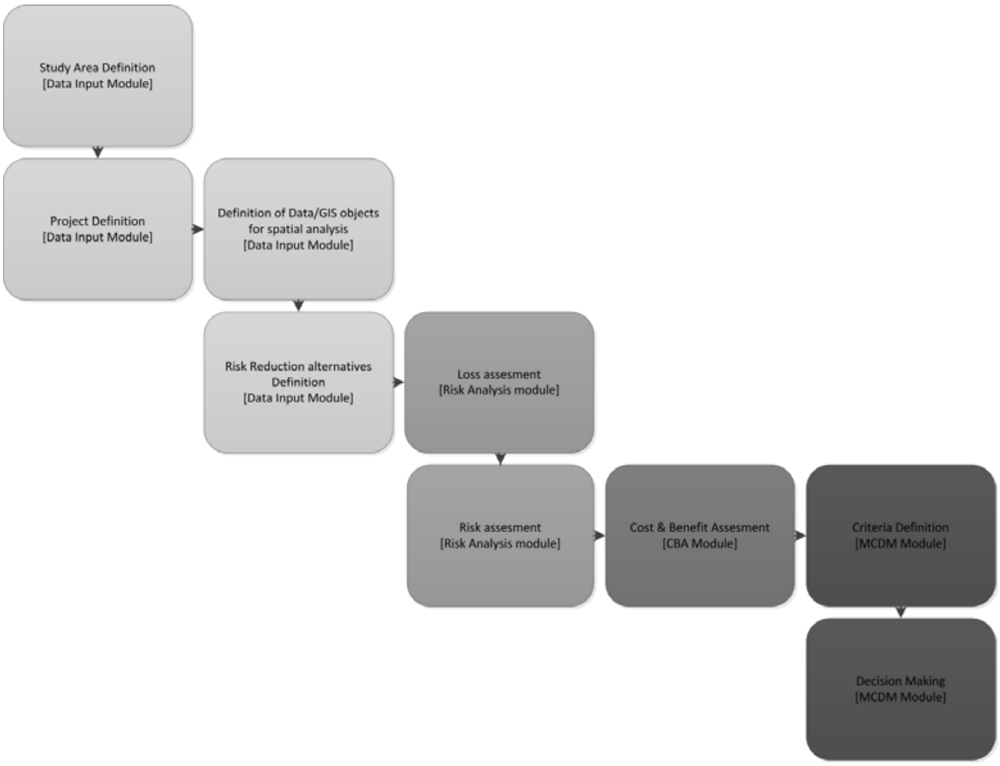


Figure 46: Workflow of CBA in the SDSS

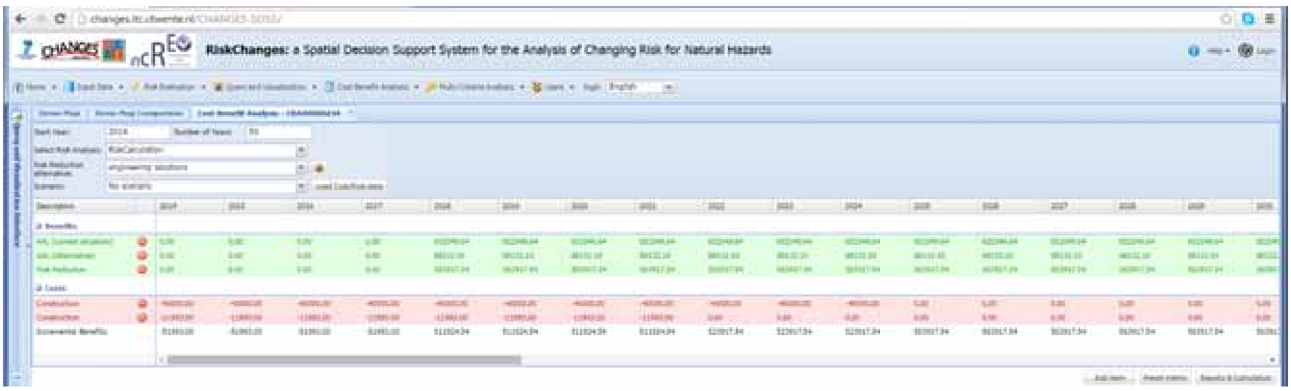


Figure 47: Main CBA Matrix view

Some information defined in the selected Alternative will be used in while conducting a Cost & Benefit analysis and is important to define it correctly. These are described as follows:

The costs are defined in the alternative and these are loaded in the CBA matrix. Typically the costs refer to the cost of build/implement the alternative and other direct and indirect costs such as construction and maintenance. Also the user can define other costs, which are an indirect consequence of the implementation of the measure like reduction of the tax income, law suits against the government among other side impacts in case of a relocation alternative for example.
For each alternative of mitigation the following information should be entered in order to be properly loaded in the CBA module:

d) **Start year:** the start year of the construction or implementation of the alternative.
e) **Lifetime:** the time span in which the risk reduction alternative is effective.
f) **When the benefits start:** From which year we can start to accrue the full benefits of the measure, in general this is when the measure is in place.
g) **Allow have incremental benefits:** With this option the user can specify an incremental amount of the expected risk reduction to be accrued, even if the measure is not completed or fully implemented.
h) **If the alternative is the current situation**: in that case all above described fields are omitted because there is not risk mitigation.

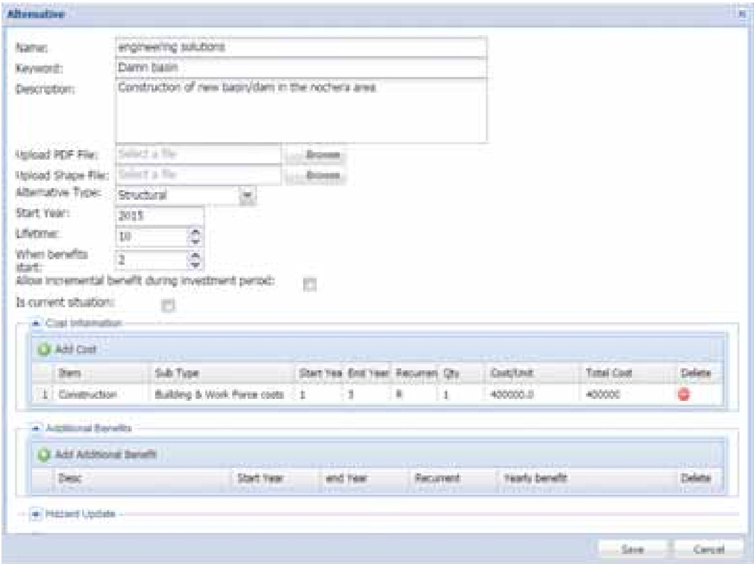


Figure 48 information from the Alternative used for CBA

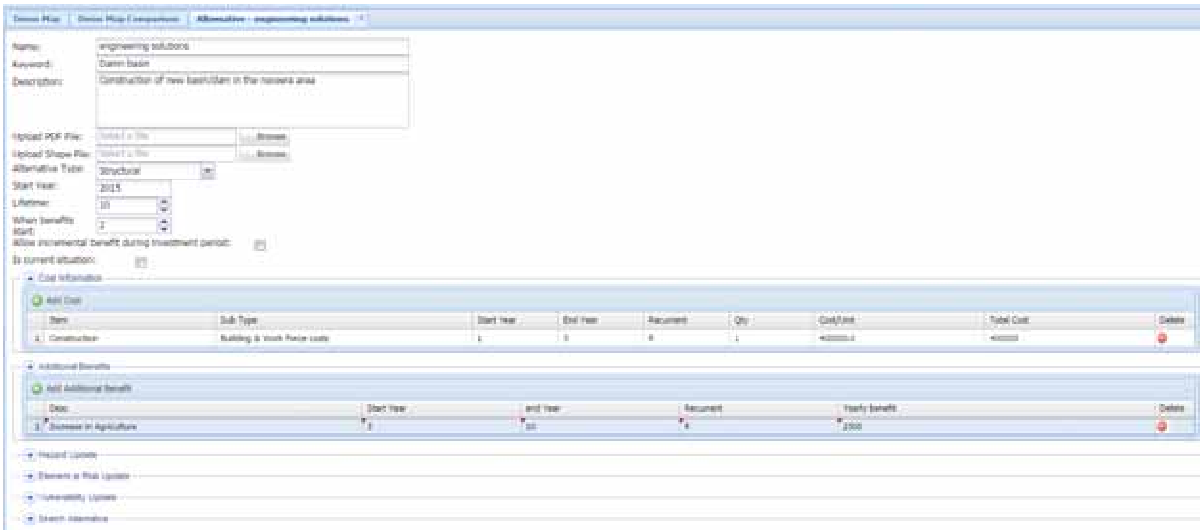


Figure 49 defining cost and benefit items

Then for each cost item, the user has to define the following:

e) **Item**: The main description of the item in question (i.e. Dam. dike, basin, etc.)
f) **SubType**: A sub-classification is possible, the user can indicate a subtype (i.e. : Labor, Materials,

Expropriations of land, etc.)

g) **Start Year**: Start year in which the cost is accrued.
h) **End Year**: End year or end of the period of the cost.
i) **Recurrent**: This indicates whether the cost is seen as a whole investment amount for the specified period and then is divided by the number of years of the defined period or if it is a recurrent amount per year for the period of validity of the cost.
j) **Quantity**: The number of the same elements to be taken into account.
k) **Unit cost**: the unitary cost per item
l) **Total Cost**: is auto-calculated by taking the unit cost and the quantity.

With this same idea the user can define additional benefits which are the consequence of the implementation of the risk reduction alternative.The following features are available in the current version in development:

- Create, Edit and Delete CBA analysis
- Integration with the risk module complete, Scenario and future years are now supported, now the values are interpolated in the grid and when the future year changes, the color of the row changes
- Different items in the matrix have different colors:
- Items loaded from risk module
- Items from Data Input module (Costs, add benefits defined in alternative)
- Custom items the user added
- Data is now exported to the MCDM to the Indicator table, the data exported are one of the selected metrics (BCR, NPV or IRR)
- User can load alternative and make changes (add costs or additional benefits, and these changes will reflect in the matrix.
- The UI of the last step was implemented with the layout Emile recommended

Regarding the alternative management module:

- Insert, edit and delete scripts added
- UI redesign and integration with CBA (cost and additional benefits)
- Vulnerability Management UI layout and some of its logic like filter the grid is completed

I also was in charge of provide training on GIT, the source code management technology we used in our project and I provided and suggested ideas for the technical definition and architecture of the system.

5.5.2 Main challenges

One of the challenges was to work efficiently in a highly geographic distributed team from different cultures and backgrounds. Also the integration with the other modules was extremely complex because the different types of data, finally the main challenge was to develop a CBA method enough flexible and integrate it with the risk module and the MCDM module. Still some parts needs further development to increase the functionality provided with this initial version.

The following features are still not completed:

- Visualization, we have to define what should visualized to compare the CBA generated data.
- Export/import to excel

The main reason was lack of time to develop these features.

5.5.3 Benefits from this Marie curie Initial Training Network

I learnt a lot about geosciences and new front end technologies for web development.I had the chance to work in a multicultural and diverse group and I meet and I worked with a great group of professionals and scientists, it was a great experience and very good for my career.

5.6 Task 3-2D : Design of a tool for probabilistic risk assessment of hydro-meteorological hazards : Designing a multi-criteria analysis module

<u>Final Report ESR 16: Roya Olyazadeh</u>

This research presents the decision analyses module based on Multi-Criteria evaluation in the framework of a Natural Risk Management Spatial Decision Support System (SDSS). The SDSS examines changes in hydro-meteorological risk and provides tools for selecting the best risk reduction alternative. Multi-Criteria Evaluation (MCE) is one of the tools that helps decision makers and spatial planners to evaluate, sort and rank the best alternatives. Combining MCE with a group decision making will improve the quality of the decision. The Application of this study is to facilitate the end users for the necessary parameters like values and weights importing from other modules such as Risk and Cost-Benefit Modules. This research demonstrates the results of MCE in changing risk over the time by using Geospatial Open Source software (OSGeo) into the practice and by comparing them by means of a numerical and graphical view within the system. We believe that this system helps decision makers to achieve better solutions by expressing their preferences and linking them within different decision analysis sessions.

5.6.1 Main Achievements

Decision making on alternatives for risk reduction planning starts with recognition of the decision problems and identifying the objectives called problem definition. Development of the alternatives and assigning the variable by decision makers to each alternative are employed to the design phase. Final phase evaluates the optimal choice by comparing the alternatives, defining indicators, assigning a weight to each and ranking them. (Criteria definition and prioritize them). The flowchart of MCE module is shown in Figure 35 with its step-by-step demonstration of the main process. Figure 36 demonstrates the main dashboard of this module that can load the results of Risk and Cost-Benefits and show into a matrix under different alternatives. User can select indicators from different decision session and other modules, besides user indicators can be added to the system as an extra information for decision analysis. Before going to “Weight”, Criteria has to be defined. This can be called standardization as well. In this step value functions are selected for each indicator plus maximum and minimum of the indicator value and constraints. As it is shown in figure 37, the indicators has to be selected then the lowest and highest value will be displayed from available data. The last step before results, is to weight each criteria. Figure 38 shows the interface for that. There are two types of prioritize Criteria: Ranking and Direct Weight. The final phase is showing the results of MCE in to the table and bar chart (Figure 39).

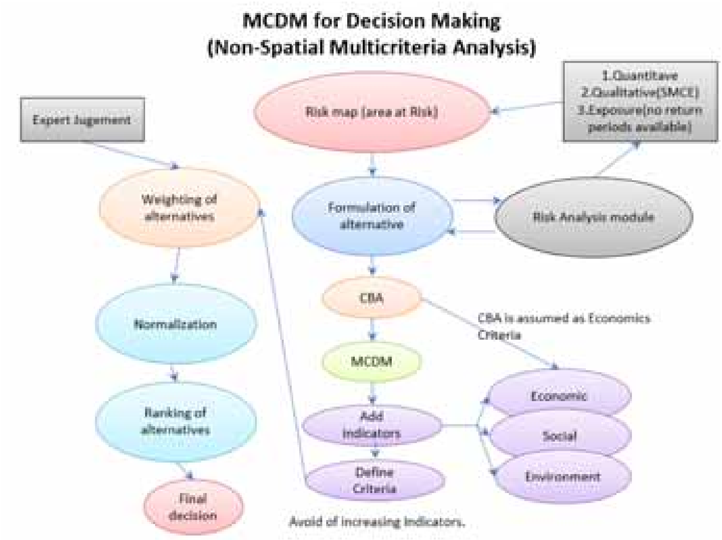
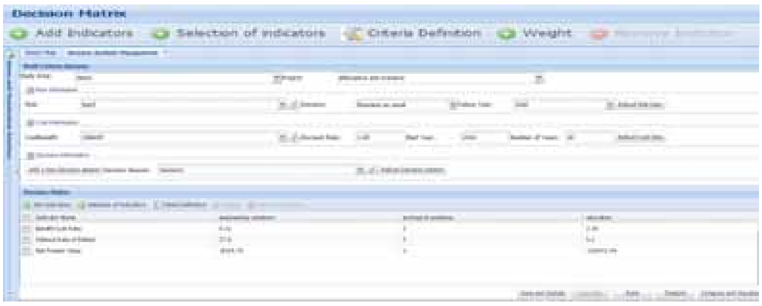


Figure 50: Flowchart of MCDM: After analysing the risk and implementing the alternatives, the user can analyse the costs of the alternatives, and make a cost-benefit analysis, leading to a prioritization of the alternatives.

The comparison session as shown in figure 40 focuses on the results for different sessions under the same project. The sessions can be selected in the combo box and the results will be automatically updated and shown as a grid (Next Figure). It is also possible to see the results in multiple bar charts as shown in the figure after. If the user wants to compare the results under different scenario or future years, different sessions for each scenarios or future years have to be created and added to this part.



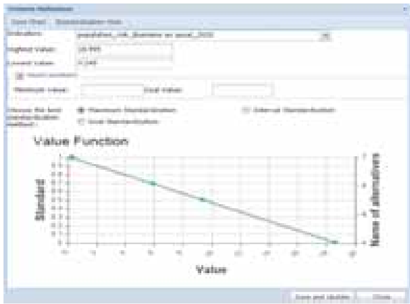


Figure 51: Main Dashboard of Multi-Criteria Evaluation Module,

Figure 52: Criteria Definition (Standardization) based on Maximum, Interval and Goal standardization

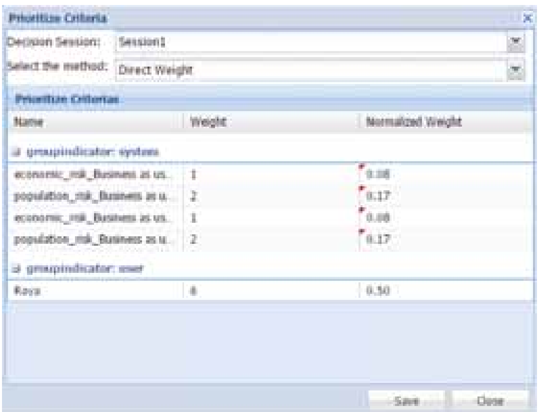


Figure 53: Criteria Definition (Standardization) based on Maximum, Interval and Goal standardization

Figure 54: Results of Multi-Criteria Evaluation in table and bar charts

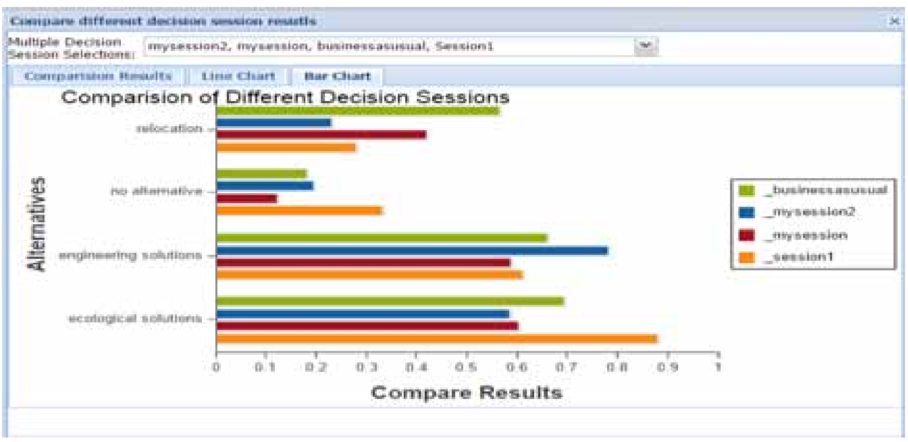


Figure 55: Comparison between different results based on different indicators and future scenarios

5.6.2 Main challenges

One of the main challenges was to carry out the results of other modules such as Risk and Cost-Benefit in Multi-Criteria Evaluation (MCE) module. As all modules were developing at the same time and MCE was the last step in this system, it needed all analysis to be calculated before entering to this module. The final results of other modules were available just two months before the project ends. It was a challenging task considering different stakeholders and experts' opinions take into account. Instead, focusing on the decision making process based on the coordinators advice has been designed out in a generic approach. Regarding the technical challenges in development of this platform, framework and the prototype, 5 members of the team have to decide for the best architecture and technologies that are easy to implement and also useful as distance work such as Git, Geoserver, Extjs library and etc.

5.6.3 Benefits from this Marie curie Initial Training Network personally

- Working in the entire international environment with people from different background and different country.
- Attending different workshops, trainings and conferences to improve our knowledge base on new technologies.
- Social and networking activities by traveling within the different institutions of the project and interaction with other ESRs.

6. Main results in relation to general objectives of WP5

Risk governance includes the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analysed and communicated and management decisions are taken (IRGC, 2005). Risk governance strategies differ greatly between the various regions and countries within Europe and with different hazards. This is in contrast with the European harmonisation in legislation. Although risk governance is applied widely its effectiveness, has not been critically reviewed whereas lessons learnt from past projects indicate a clear need for this, especially communication. In view of the given differences between cultures and socio-economic settings in addition to individual factors, good risk governance should focus on common procedural requirements for different phases of risk governance. The legitimacy of risk reduction measures is also based on successful risk governance. It needs to take into account the state-of-the-art of both the Quantitative Risk Assessment and the relevant aspects of risk perception, institutional settings, history and constraints. This could give insight in why hydro-geomorphologic events are often undervalued by the authorities and the general public largely due to their lack of awareness. The changes in hazard intensity (WP1), exposed elements at risk (WP2) and risk scenarios (WP3) as a result of on-going and future environmental changes, pose a large challenge to organisations involved in risk management. Part of this Work Package is an analysis of the risk governance strategies in the four countries involved (France, Italy, Poland and Romania) in its European context. The importance of climate change and environmental change awareness among national and local governments, and also among local residents within the study areas will be analyzed. Stakeholders involvement will be needed throughout the entire project. The methods for hazard and risk assessment developed in earlier WPs are communicated with local authorities and the affected individuals and communities. Scenarios for risk reduction will be agreed on by mutual dialogue between researchers and all stakeholders. The effectiveness of risk communication strategies will be analysed, focusing on the possible effects of climate and environmental changes on hydro-meteorological hazards and their impacts. Suitable training materials were developed for different stakeholders.

6.1 Task 5-1 : Comparing risk governance strategies for different EU countries

This was carried out with a focus on the difference between Western and Eastern European countries. Risk acceptance criteria were evaluated, and stakeholder analysis were carried out.This was carried out by TUD and TUDO, with input from CNRS, AS, and PC-FVG. This resulted in the deliverable: D5.1: Comparing risk government strategies

6.2 Task 5-2: Development of the risk governance framework

Final Report ESR 11: Teresa Sprague

6.2.1 Main achievements

Conceptual framework: development of the risk governance framework as a system

The first of the main achievements from the research was the development and construction of a conceptual framework highlighting the inputs, processes, and outputs of risk governance. This builds upon the previous frameworks developed by the International Risk Governance Council (IRGC) which generated a framework comprised of two spheres (management and assessment of risks) with risk communication as a central node playing into all components of these spheres. The framework developed by ESR-11 within the CHANGES project takes a broader approach in understanding the contextual components of a given space in which risk governance processes occur (e.g. assessment, management, and risk communication across decision-making and action taking). These are featured as working toward the goal of reducing disaster risks and include feedback loops between the three main parts of the conceptual framework. The spatial component of the conceptual framework borrows from the works of Cutter ("hazards of place" model) and as well as Holling ("spatial mosaic") in understanding the variation of what makes a given space a unique context in which risk governance processes operate.

One key innovative aspect of the framework is the use of equations to demonstrate the relationships between the different parts of the framework. The equations are not meant to be used for calculation, but rather to provide a clear visualization of these relationships. Though equations have often been used for demonstrating concepts of risk and vulnerability (e.g. Blaikie's PAR model), this kind of visualization is arguably not as often seen in attempting to demonstrate concepts specific to risk governance. *This achievement is considered to be the core theoretical contribution of the research.*

Development of "good" risk governance category and indicator system
The research developed a means by which one can operationalize the concepts of risk governance through the creation of a category and indicator system. This system was created in the frame of what is commonly assumed to be "good" governance within a primarily Western context using an in-depth analysis of EU policy documents. The documents (including both binding Directives and Decisions, and non-binding White Papers and Communications) were chosen based on their applicability to disaster risk management, governance, and good governance themes. The result of this analysis was the creation of a 12-category system with supporting indicators for each category. The system was revised according to a context validity (integration of preliminary empirical analysis of interview transcripts) and replicability (selected double coding by a research assistant) test. The system is currently being used as a comparative analysis tool for the empirical evidence base gathered from interviews conducted within all four case of the CHANGES case study sites. *This achievement serves as the key contribution to implications for policy analysis.*

Gathering of substantial empirical evidence base (100+ interviews)
A further research achievement lies in the substantial collection of empirical data from the over 100 interviews in the four sites. The qualitative evidence supports establishing an on-the-ground understanding of in-practice strategies with emphasis placed on providing input from both regional and local level stakeholders as well a wide range of stakeholder types (e.g. such as but not limited to mayors, technicians, community leaders, water board authorities, environmental protection agencies, spatial planners, geological survey authorities, civil protection, fire departments, police, regional level administrative authorities). Representation of both levels and a wide range (at least 15 types of stakeholders) was met in all cases. *This achievement provides a significant contribution to practical empirical evidence to be used in understanding risk governance strategies at a local level.*

Dissemination of results to case study stakeholders
Efforts were made through the work of ESR-11 to furthermore give back to the stakeholders, scientists, and communities who provided their time and input into the gathering of the empirical evidence base. This is marked as an achievement in that dissemination, though an important part of the research process, is often an afterthought and given little time and consideration at the end of scientific projects. Dissemination activities were carried out through collaboration with our case study site partners (IGRAC in Romania, IRM in Poland, CNR in Italy, and CNRS in France (activities planned)). Collaboration was also made with other ESRs to attempt a comprehensive dissemination of the CHANGES research in each case. Presentations of results were given by CHANGES researchers, hard copy dissemination booklets and materials were provided, and discussion and feedback was pursued and encouraged with the stakeholders. This feedback helps serve as a validation and additional input into the research and provides a further avenue for stakeholders to contribute to and integrate their comments and opinions into the formulation of the research results (providing a means through which two-way communication is possible). This also helps ensure applicability to local practices and stakeholder issues. Reports of the dissemination are underway and one has been published on the CHANGES website for continued dissemination. *This achievement contributes to the overall impact and outreach of the CHANGES project with a focus on two-way communication between science and practice.*

6.2.2 Main challenges

Several challenges arose through the research process. These are as follows:

- **Making tangible the intangible concepts:** the topic, when first understood within the structure of the project, appeared to be a catch-all for all of the social, intangible aspects of managing changing hydro-meteorological risks. The topic appeared to be connected to every aspect of the project without a clear understanding of these connections and what were the expected inputs and outcomes with the research of other ESRs. Though this was attempted to be remedied through the individual and collective research work, this proved to be a challenge throughout the course of the project period. On the individual scale, efforts were made to make a clear demonstration of the concepts (e.g. through the conceptual framework with equations) and how to operationalize typically intangible concepts like "good" governance (e.g. through the category and indicator system).

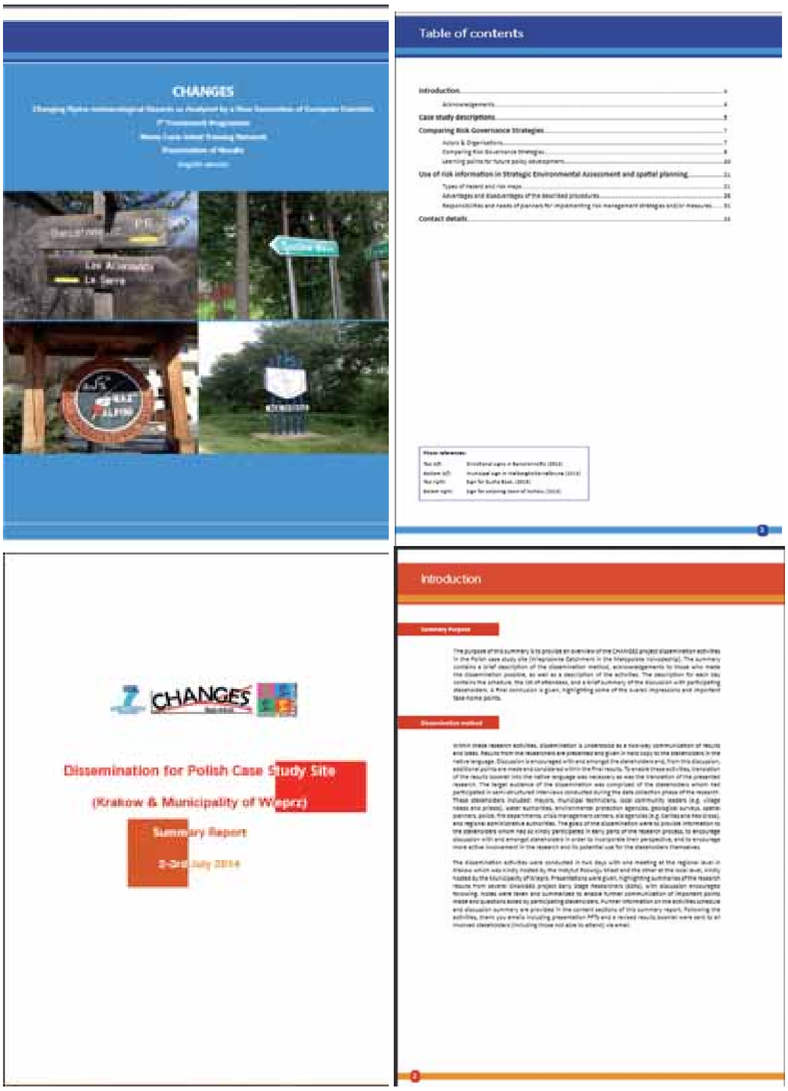


Figure 56: Above: Image of Dissemination Booklet, 35pgs. Below: Images of Dissemination Report, Poland, 13pgs

- **Gathering and processing of intensely qualitative data:** though rewarding, preparing and conducting interviews and especially processing their output is a challenging, time-consuming, and labor intensive process. The completion of the final dissertation requires a length of time beyond the period of the project due to the intensity of the continued work to finalize the analysis and results of the empirical evidence base from these interviews. The finalization is expected, once completed, to provide a comparative analysis among the four cases and in-practice evidence to support more successful, future policy development at both micro (local), meso (regional), and macro (EU) levels.
- **Dissemination efforts:** similarly to the previous point, the short timeframe of the project allowed also for a short time in which to provide a forum for the presentation of results and discussion thereof with stakeholders in each case study. Efforts for dissemination in the last of the case study sites (France) are underway with the expected completion to be in summer of 2015.

6.2.3 Benefits from the Marie Curie ITN

There have been a plethora of opportunities that have included (and continue to include) the following:

- **Networking (still using these networks):** one of the biggest opportunities within the Marie Curie experience has been networking. This is true of the networking activities in working with the fellow ESRs as well as with the project partners and affiliates. I am still using the network connections I have made during the project period and have seen expansion of this into secondary networks stemming from the initial contacts made within the project.
- **Travel:** the funding available for travel is one of the key benefits and enables not only greater opportunity for networking activities through attending conferences and workshops, but also

enables practical fieldwork that otherwise would not be possible. Additional benefits with travel afforded through the project include the opportunity to explore and appreciate different landscapes and cultures in Europe. As a student from the USA, this is a personal benefit and encourages greater interest in continuing research within a European context.

- **Scientific research:** experience within the project as well as from trainings provided with the hosting institute (TUDO) have strengthened skills in scientific research, especially in terms of scientific method and practical work.
- **Interdisciplinary experience:** The project also exposes students to a wide variety of scientific disciplines ranging from the very physical (geomorphological sciences) to the very social (aspects of governance and communication). The encouragement of establishing a more holistic understanding of the issues of risk and disaster risk reduction has been an added benefit. This has been achieved through collaborations and discussions with colleagues from different disciplines within and outside of CHANGES meetings and activities.
- **Intercultural working environment:** the fact that the participants in this project have come from literally all around the globe is an extremely beneficial aspect. Learning from other colleagues and their cultures has also been possible through the use of secondments and numerous travel opportunities as well as the time spent working outside of one's country of origin.
- **Field research:** extensive field research was made possible due to project resources and has enabled substantial experience in methods such as group discussion, semi-structured interviews, and observation. This has been supported and complemented by opportunities provided from the host institute (TUDO) in the courses given by the Faculty of Spatial Planning Graduate Programme (esp. for case study methods).
- **Teaching:** the connections established through networking and (primarily) through the host institute has also enabled a wide variety of teaching opportunities including: giving guest lectures; advising and supporting both Master and Bachelor students; advising advanced Bachelor student group projects and field excursions; providing seminars for a Master's course.
- **Proposal writing:** several opportunities have also emerged in involvement in proposal writing through the host institute. This has been supported also through using connections within and beyond the CHANGES consortium partners.
- **Dissemination techniques:** the research enabled by this network has also provided the means to expand dissemination techniques. Though this is still an ongoing process, the resources available to the project and through the host institute have granted development in skills as to how to conduct dissemination with stakeholders and what are good practices and important learning points for future improvement.
- **Presentation skills & experience:** throughout the project duration, there has been a considerable number of presentations given through CHANGES activities, conference participation, external networking opportunities and host institute activities. This has allowed for further development of presentation skills and experience with a wide range of audiences and disciplines.
- **Publication skills & experience:** through both the project and the host institute, skills in publication of research have also been expanded. This stems from initial experience both in article writing for scientific journals, grey literature creation for public use, and book chapter writing in related disciplines.

6.3 Task 5-3: Design of a web-based visualization module

Final Report ESR 17: Irina Cristal

One of the main components of the Web-based Spatial Decision Support System (SDSS) developed in the WP3 of the CHANGES project is the development of web-based risk communication and visualization methods. Key goal of this component was to efficiently exploit the large amount of risk-related data in relation to the needs of the end-users, as to facilitate the data retrieval and to apply appropriate graphical representations. Thus, the output of the study integrates a filtering mechanism, web-GIS applications and comparison tools into an interactive user interface, providing a better understanding of the data within the SDSS and supporting the decision making process.

Despite the pure technical aspect of this activity, the broader scope of the project was to create a multicultural and interdisciplinary environment by bringing together scientists and stakeholders. During the 18 months project, plethora of meetings had been held in order to exchange knowledge and experience within and outside the CHANGES network. Most important meetings for completing the

SDSS project were the eleven “coding weeks” hosted at different partner’s organizations and the weekly teleconferences. The meetings with the CHANGES group and the ability to attend workshops and conferences influenced positively to the personal communicational and intercultural skills. The challenges related to the distant working contributed to the character-related aspects, such as self-motivation and the ability to work independently, but also to a range of personal skills, such as problem-solving and the ability to plan and set priorities.
All these contribute to a solid ground for the ESRs to further proceed with their academic career.

6.3.1 Main achievements

The most significant outputs can be categorized into social research in order to collect valuable information about the users and the technological achievements, as to provide usable and functional visualization tools, based on the users’ needs.

Working with Stakeholder – understanding the users

Due to the limited time and resources, the potential users were evaluated at different stages of the project, and whenever was feasible in collaboration with other ESRs (Tess, Marie, Kathrin, Zar Chi) or other related projects (InCreo). Dissemination of preliminary results and feedback questionnaires were provided to different types of end users, according to the requirements of the SDSS.
The following actions have been performed in order to collect information and evaluate the potential users of the system.

- Observation protocol in Alpago, Italy. The initiative for this action aroused from the need to identify the potential users of the SDSS. Although the meeting was held by the the InCreo project , the suggestion to assist the meeting and discuss with the stakeholders offered the opportunity to perform an observation protocol, which stood a starting point for understanding the cultural particularities and distinguish important differences between the case study areas. The participants were mainly civil protection officers and municipality employees. Main findings from this action were related to the risk culture issues.
- Usability evaluation in Poland.Feedback questionnaires were provided, after the visualization tool presentation, to two main groups of potential users during dissemination activities in Poland (Krakow and Wieprz). The participants were mainly urban planners, students and municipality employees. The activity was organized in collaboration with other colleagues from CHANGES (ESR-11: Teresa Sprague, ESR-08: Kathrin Prenger-Berninghoff, and ESR-09: Zar Chi Aye), the partners from the Institute of Urban Development (IRM) in Krakow (Wiktor Glowacki and Janusz Komenda) and the municipality of Wieprz.
- Usability evaluation in Romania.The activity consisted of two parts: one day presentation and usability evaluation through questionnaires in Buzau Municipality, and five days assisting the Visualization/Risk communication exhibition in Patarlagele Natural Hazards Research Centre located in Buzau Subcarpathians (case study area). The exhibition was organized by ESR-12, Marie Charrière in order to collect information regarding the attractiveness of visuals for risk communication. The whole activity was supported and organized in collaboration with colleagues from CHANGES (ESR-12: Marie Charrière, ESR-05: Roxana Liliana Ciurean, ESR-09: Zar Chi Aye and ESR-11: Teresa Sprague) and Dr. Mihai Micu from the Institute of Geography of the Romanian Academy in Bucharest (IGRAC).
- Usability evaluation in Germany.Complementary information on the visualization tool usability was collected from students of diverse nationalities, and having geo-informatics background during the GeoMundus conference in Munster. The methodology was kept the same: presentation of the tool and completion of the usability questionnaires from the participants.
- Usability evaluation from expertsThe same questionnaire was given to the 11 ESRs from the CHANGES project, after presenting the whole system with the focus on the visualization tools, during the CHANGES final meeting in Italy. Initial scope was to perform this activity with the stakeholders. However, due to the lack of time, the idea was to get the feedback from the present ESRs, by considering them as the most appropriate users of the system. Important aspect is that the ESRs have diverse backgrounds and can cover a wide range of expert users.

Implementation of the visualization tools

The visualization tools within the current project include the graphical representation and interactivity of risk-related data, which are required at all stages of usage of the SDSS.
The primary goal of visualization is to enhance the understanding of the data and to facilitate the decision making. The design of these tools was prudently carried out with regard to the users’ needs

and the technical requirements of the system. Main components are: data retrieval or filtering, data display through a web GIS environment and data comparison.

Data Filtering

A large number of data sets are stored in the database and published to the GeoServer after the first two stages of the use of the system (Data Uploading and Loss/Risk calculation). This complicates the data navigation process. In order to simplify it, the visualization module included a filtering tool, which guides the end-users through a querying mechanism and leads to the visualization of desired data.
The querying interface reflects the database structure of the SDSS and starts with the selection of the study area and the project. The user is required to specify the visualization parameters, which are determined by the particular data category:

- the **input data category** is the data uploaded to the system at the initial phase
- the **loss data category** is the data resulting after the loss calculation module, and
- the **risk data category** derives from the risk analysis module.

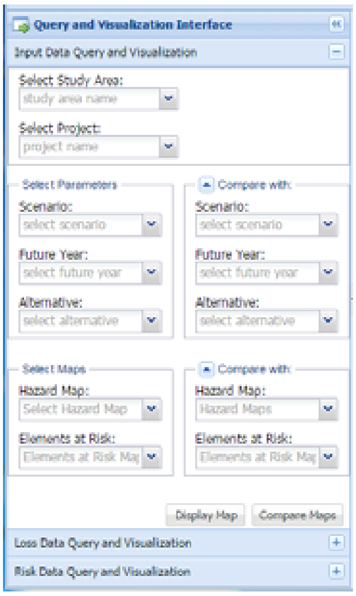


Figure 57. Data filtering interface

Web-GIS application

The main visualization interface is basically a single-map web-GIS application. In order to select and visualize particular data, the user should access the Query and visualization menu. Basic functionalities of the web-GIS are: Navigation, Measurement tool, Query feature, Geo-location, Opacity Slider, Changing layers appearance, remove layer, Legend, and Print map.
The map is updated every time the user selects spatial data from the query and visualization interface and presses the "display map" button.

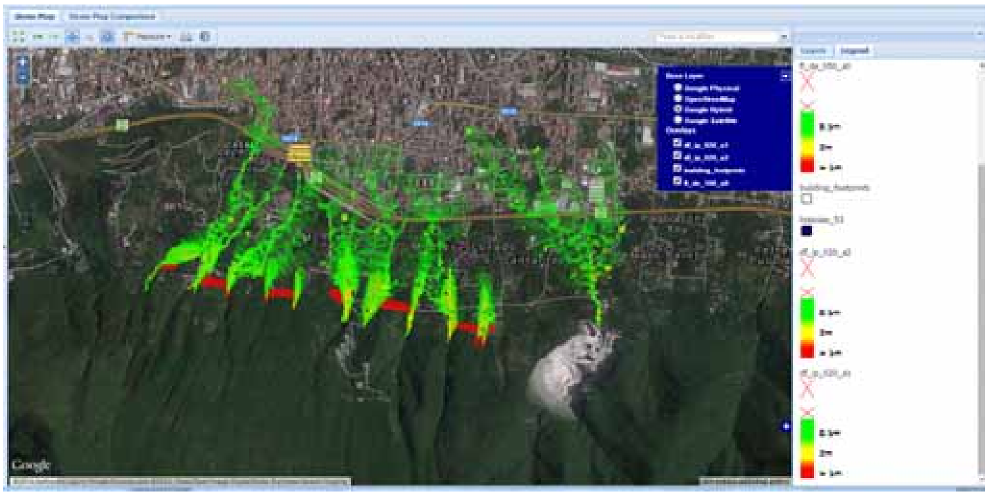


Figure 58. Web GIS interface

Data Comparison

Data comparison consists of the three web GIS applications. The first one is the swiping application, which is composed by two map panels showing one region as a whole in both panels. The user can update/visualize the spatial data from the querying and visualization interface independently on each map panel. By moving the middle bar, the user can perform the visual comparison between the data.

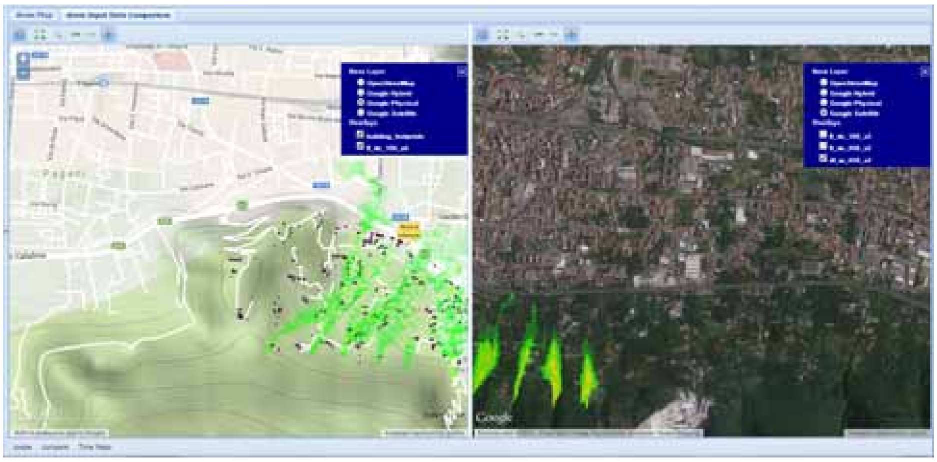


Figure 59. Data comparison: Swiping tool

The second application is the side by side map comparison. Here the two map panels are showing two different maps of the same region. Visual comparison is performed by zooming and panning. As the two maps are "linked", the navigation performed on one map will cause the same action on the other map. Furthermore, the feature info will provide more details needed for comparison.

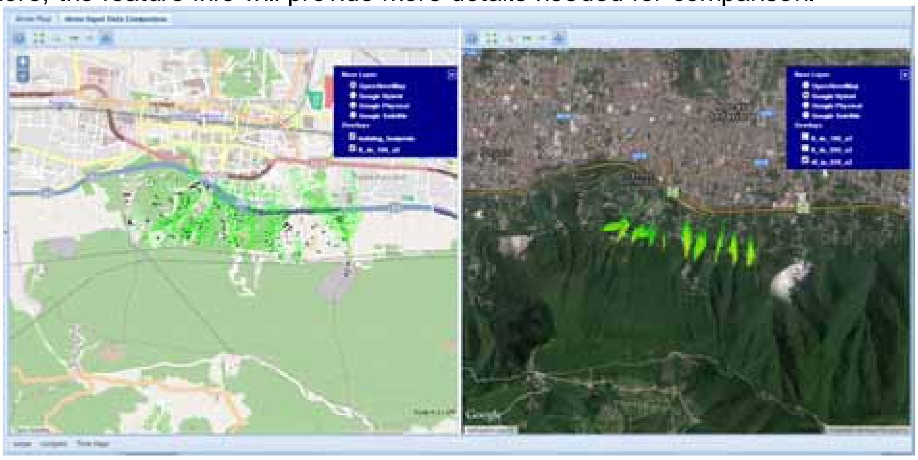


Figure 60. Side by side map comparison

Finally, the map animation application offers differences' detections through sequence animation. By selecting layers in the Querying and visualization interface an animated gif image is generated from the multiple layers in the WMS request.

6.3.2 Main challenges

Working from distance

The members of the SDSS team, consisted of five ESRs, were located in five different institutions. Usually the distant work makes difficult the team collaboration, especially in a software project. However, this challenge brought more creativity in finding solutions from technical and personal point of view. Some of the practical solutions are listed below:

- Meetings and coding weeks were organized almost every month, in order to bring together the developers of the system.
- Special software has been used to store, maintain and update the code from distance.
- The architecture was designed in a way to allow working individually.

Unclear starting point

At the beginning of the SDSS project, the requirements and the responsibilities were not clear. We didn't have a clear picture of the system, of the users of the system or the individual tasks. This created at first disagreements and conflicts, but over time it proved to be a catalyst in building up important skills needed when working in an inhomogeneous environment or when adjusting to new changes. Moreover, this challenge amplified personal skills related to decision making and problem-solving.

Short period, limited resources
The extent of the work in the given period of time, including the initial stage of learning and the parallel activities, such as academic writing, presentations and conferences' attendance is insufficient to finalize a software project. However, this gave us the opportunity to cultivate the ability to plan and set priorities. As a result we have functional pilot version of the SDSS, which gives room for more development and alterations.

6.3.3 Personal Benefits

As mentioned previously, the challenges of the project had cultivated personal and interpersonal skills. Efficient team working, problem-solving ability, setting priorities, and intercultural integration are only a few personal benefits obtained during this project.
On the other hand, the travel ability offered the opportunity to attend conferences and workshops, and along with that helped to improve communication skills by presenting the personal work to a large community of scientists. At a professional level, the CHANGES network created an environment for collaboration and knowledge exchange; it can be considered the first step to a successful scientific career. Since this project lasted only 18 months, the limitations in scientific activities were unavoidable. The ESRs involved in the project lacked the opportunity of applying a proper scientific methodology, or to attend educational seminars due to the limited time. Therefore, their role was more executional and goal-oriented. However, the outcome is satisfying and the personal achievements are significant.

6.4 Task 5-4: Risk visualizartion and communication

<u>Final Report ESR 12: Marie Charriere</u>

6.4.1 Main achievements

Raising awareness is a key action for Disaster Risk Reduction and one way to achieve it is through visual risk communication. Insurance of the effectiveness of risk communication efforts can only be achieved by proceeding to their evaluation. Current research in the field focuses on users' requirements, ability to understand the content or satisfaction rather than on real impacts. Moreover, most of the studies are performed in lab-type environements and thus their conclusions might not be fully valid in real life settings. Therefore, the choice was made to test the effectiveness of a real communication effort. The approach used to create this communication effort derived from collaborative approach principles, i.e. the research should be beneficial and significant for both the science and the stakeholders and created in collaboration with the latter. The outcome of this process was the 'Alerte' exhibition held in Barcelonnette (Ubaye Valley) during the winter 2013-2014. Its impact on the risk awareness of the population was assessed using a pre-test/post-test research design complemented by Radio-Frequency Identification method. The results help to understand how risk awareness can be measured and provide guidelines for future communication efforts.

- **Collaborative research**

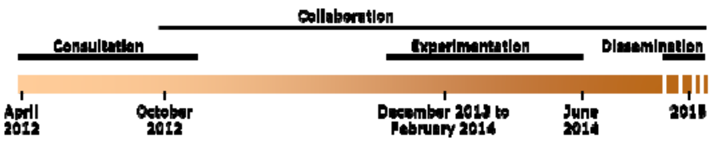


Figure 61: Timeline of the collaborative approach that was used to develop this research and the associated real communication effort.

Intense collaboration was established with local and regional stakeholders (politicians and technicians). Informal meetings were first organized to determine the communication context, the audience of the project and the specific testing activity. Children and elderly were identified as the most appropriate audience by the stakeholders and the idea to create an exhibition at the Public Library of Barcelonnette was drawn. This was pursued as the stakeholders understood the scientific aspect of the project and offered support with organization and fund raising. The collaboration with the stakeholders continued while designing the exhibition. They not only provided data and material to be exhibited but shaped the content as well. Initially the focus was on landslides and floods but it was requested to include earthquakes and snow avalanches as well. In addition, the stakeholders established contacts with inhabitants that were later interviewed to provide witnesses' stories.

- **The Alerte exhibition**

The “Alerte” exhibition was held at the public library of Barcelonnette between November 2013 and February 2014. The entrance was free of charge. The exhibits covered the topic of natural hazards and associated risks using local examples of physical phenomena and mitigation measures of the Ubaye valley. Visitors could enjoy: 15 posters, a timeline of events, a flood scale model, a seismograph, 4 videos of events, 15 videos of witnesses, an interactive Google Earth map and an emergency kit. Approximately 500 persons visited the exhibition “Alerte”. This accounts for a bit less than 20% of the population of the town of Barcelonnette. Half of the people, mostly adults, came to the exhibition independently. They were encouraged to fill a satisfaction survey after the visit. The other half were invited to visit the exhibition and participated to the full research activity. The focus was on children.

Figure 62: Examples of exhibits displayed at the exhibition: (1) flood scale model based on the DEM of Barcelonnette, (2) Posters on floods and debris flows, (3) Google Earth map with major events and (4) Emergency kit.

- **Changes in awareness**

In order to evaluate the change in awareness produced by the visit of the exhibition, a pre-test/post-test research design was used. Several indicators stemmed from Enders’s framework on measuring awareness and preparedness (2001) as well as other studies were assessed. Pre-test was conducted right before the visit and the post-test right after it.

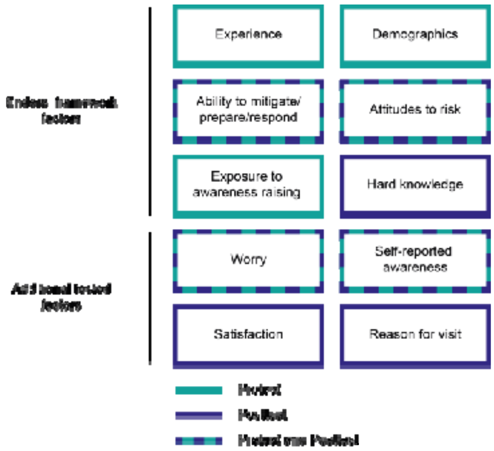
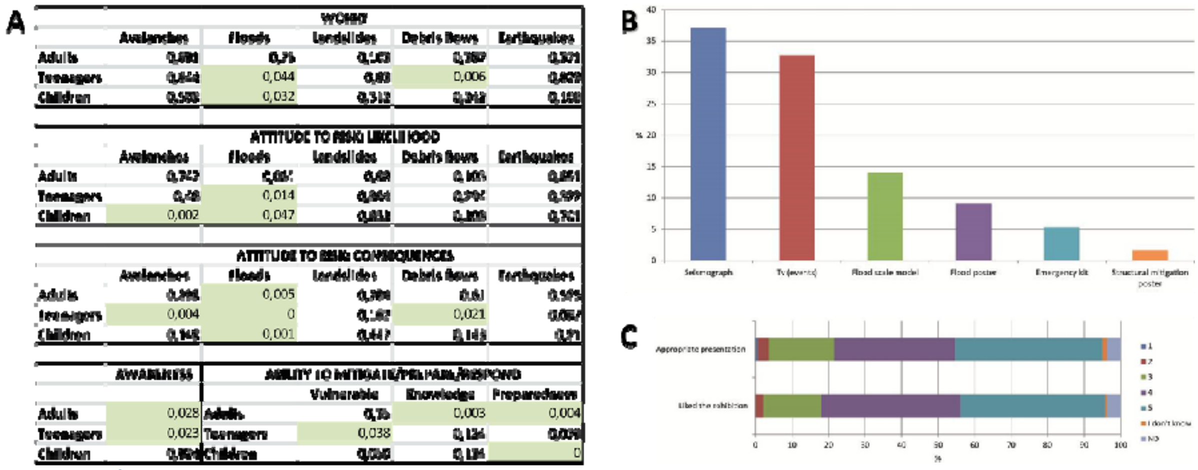


Figure 63: Indicators that were measured using a pre-test/post-test research design.

The changes’ analysis is performed on the factors *‘worry’, ‘attitude to risk’* (in relation to likelihood and consequences of events), *‘self-reported awareness’* and *‘ability to mitigate/prepare/respond’*. The questions were asked using a 5-points Likert scale (1= not at all, 5=completely) and thus the data

produced are ordinal. Consequently, non-parametric statistical analysis is the most appropriate. In this case we used the Wilcoxon sign-ranked tests.
Results shows that significant changes occurred mainly in relation to flood awareness, a natural hazard infrequent in the valley (the last major flood occurred in the 1957) in contrast with earthquakes that are very frequent and for which no change was observed. Teenagers present the most changes while adults' scores related to specific natural hazards did not change (except one). On the contrary more general indicators (*'self-reported awareness'* and *'ability to mitigate/prepare/respond'*) show changes for this group.



WORRY	Avalanches	Floods	Landslides	Debris flows	Earthquakes
Adults	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Teenagers	[illegible]	0,044	[illegible]	0,006	[illegible]
Children	[illegible]	0,032	[illegible]	[illegible]	[illegible]

ATTITUDE TO RISK LIKELIHOOD	Avalanches	Floods	Landslides	Debris flows	Earthquakes
Adults	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Teenagers	[illegible]	0,014	[illegible]	[illegible]	[illegible]
Children	0,002	0,047	[illegible]	[illegible]	[illegible]

ATTITUDE TO RISK CONSEQUENCES	Avalanches	Floods	Landslides	Debris flows	Earthquakes
Adults	[illegible]	0,005	[illegible]	[illegible]	[illegible]
Teenagers	0,004	0	[illegible]	0,021	[illegible]
Children	[illegible]	0,001	[illegible]	[illegible]	[illegible]

	AWARENESS
Adults	0,028
Teenagers	0,023
Children	[illegible]

ABILITY TO MITIGATE/PREPARE/RESPOND	Vulnerable	Knowledge	Preparedness
Adults	[illegible]	0,003	0,004
Teenagers	0,038	[illegible]	[illegible]
Children	[illegible]	[illegible]	0

Figure 64: A) Results of the change analysis using the non-parametric Wilcoxon sign-ranked test. The number displayed correspond to the significance level. Green color indicates a significant change. In all cases, the analysis was performed on negative ranks, indicating an increase in the scores. B) Relative time spent by the children in front of the different exhibits measured using the RFID technology. The seismograph and the TV showing videos of events were the most attractive exhibits. C) Percentages of different scores for 2 of the satisfaction questions.

- **Attractiveness & satisfaction**

The relative attractiveness of some of the exhibits was measured by tracking the visitors using the wireless Radio Frequency Identification (RFID) technology. 8 antennas were placed in the exhibition to do so. The results show that the children spent most of their time in front of the seismograph where they could simulate an earthquake (37% of the time) and in front of the TV that was displaying videos of events (33% of the time). Direct observation showed that the children spent a lot of time in front of the tablet computers looking at the videos of witnesses while adults read the posters more. These results confirm the hypothesis that children are more attracted by interactive (seismograph and tablet computers) or familiar (TV) communication tools.
The satisfaction of the visitors was measured using a Likert scale survey. Adults and teenagers visitors (both independent and participants) were highly satisfied by the exhibition and its presentation. More than 70% of the surveyed persons gave a score of 4 or 5 (1 being not at all and 5 completely) to the satisfaction indicators.

- **Conclusion & future actions**

This study improved the understanding of how to measure awareness. Results showed that visitors increased their awareness by visiting the exhibition. Moreover, the hypothesis that communication tools are not universal was confirmed: children preferred interactive tools and adults traditional ones. The collaborative approach constrains scientists as demands of the stakeholders have to be met, in particular in terms of timeframe and content. However, this study was, in addition to be scientifically relevant, socially beneficial. Reinforcement of the relationships between stakeholders, their engagement in science, the triggering of memories and their sharing, an exchange between generations at and outside of the exhibition and the promotion of further communication efforts were observed.
To complete the collaborative approach, a dissemination phase will take place in early summer 2015. The goal is to present the results of the scientific activity and to discuss them with the participants. The second goal is to determine if this activity triggered changes in the risk communication context of the Ubaye valley. Scientific developments include comparison of different statistical tests as well as the conduct of a ordinal regression analysis in order to understand the awareness changes that were observed. Therefore, there will be an understanding of the influence of previous experience, prior exposure to awareness raising and demographic characteristics.

6.4.2 Main challenges

- Making tangible the intangible concepts: the topic, when first understood within the structure of the project, appeared to be a catch-all for all of the social, intangible aspects of managing changing hydro-meteorological risks. The topic appeared to be connected to every aspect of the project without a clear understanding of these connections and what were the expected inputs and outcomes with the research of other ESRs. Though this was attempted to be remedied through the individual and collective research work, this proved to be a challenge throughout the course of the project period. On the individual scale, efforts were made to make a clear demonstration of the concepts (e.g. through the conceptual framework with equations) and how to operationalize typically intangible concepts like “good” governance (e.g. through the category and indicator system).
- Gathering and processing of intensely qualitative data: though rewarding, preparing and conducting interviews and especially processing their output is a challenging, time-consuming, and labor intensive process. The completion of the final dissertation requires a length of time beyond the period of the project due to the intensity of the continued work to finalize the analysis and results of the empirical evidence base from these interviews. The finalization is expected, once completed, to provide a comparative analysis among the four cases and in-practice evidence to support more successful, future policy development at both micro (local), meso (regional), and macro (EU) levels.
- Dissemination efforts: similarly to the previous point, the short timeframe of the project allowed also for a short time in which to provide a forum for the presentation of results and discussion thereof with stakeholders in each case study. Efforts for dissemination in the last of the case study sites (France) are underway with the expected completion to be in summer of 2015.
- Another main challenge during CHANGES ITN was to finalize scientific papers. This is due to the choice of the topic that induced a slow research process. A long phase of learning needed to acquire sufficient knowledge to conduct research, the choice of collaborative approach required an prolonged interaction with stakeholders and the lack of strong expertise in social sciences related to communication science in the consortium were the reasons for this slow research process.
- Another challenge was to reconcile the goal and timeframe of the personal research project with the one of the full project. One example concerns the collaboration between ESRs in terms of scientific outcomes. While collaboration was very effective in order to plan field work and interaction with stakeholders, writing scientific papers together was difficult. This is mainly due to the variable requirements for defending a PhD, some universities requiring publications and some not. Considering the timeframe of the project, the different personal schedules as well as the variety of research topics, there was limited time and incentives to participate to activities that are not directly beneficial to its own work.

6.4.3 Benefits of the Marie Curie Network

There have been a plethora of opportunities that have included (and continue to include) the following:

- Networking (still using these networks): one of the biggest opportunities within the Marie Curie experience has been networking. This is true of the networking activities in working with the fellow ESRs as well as with the project partners and affiliates. I am still using the network connections I have made during the project period and have seen expansion of this into secondary networks stemming from the initial contacts made within the project.
- Travel: the funding available for travel is one of the key benefits and enables not only greater opportunity for networking activities through attending conferences and workshops, but also enables practical fieldwork that otherwise would not be possible. Additional benefits with travel afforded through the project include the opportunity to explore and appreciate different landscapes and cultures in Europe. As a student from the USA, this is a personal benefit and encourages greater interest in continuing research within a European context.
- Scientific research: experience within the project as well as from trainings provided with the hosting institute (TUDO) have strengthened skills in scientific research, especially in terms of scientific method and practical work.
- Interdisciplinary experience: The project also exposes students to a wide variety of scientific disciplines ranging from the very physical (geomorphological sciences) to the very social (aspects of governance and communication). The encouragement of establishing a more holistic understanding of the issues of risk and disaster risk reduction has been an added

benefit. This has been achieved through collaborations and discussions with colleagues from different disciplines within and outside of CHANGES meetings and activities.

- Intercultural working environment: the fact that the participants in this project have come from literally all around the globe is an extremely beneficial aspect. Learning from other colleagues and their cultures has also been possible through the use of secondments and numerous travel opportunities as well as the time spent working outside of one's country of origin.
- Field research: extensive field research was made possible due to project resources and has enabled substantial experience in methods such as group discussion, semi-structured interviews, and observation. This has been supported and complemented by opportunities provided from the host institute (TUDO) in the courses given by the Faculty of Spatial Planning Graduate Programme (esp. for case study methods).
- Teaching: the connections established through networking and (primarily) through the host institute has also enabled a wide variety of teaching opportunities including: giving guest lectures; advising and supporting both Master and Bachelor students; advising advanced Bachelor student group projects and field excursions; providing seminars for a Master's course.
- Proposal writing: several opportunities have also emerged in involvement in proposal writing through the host institute. This has been supported also through using connections within and beyond the CHANGES consortium partners.
- Dissemination techniques: the research enabled by this network has also provided the means to expand dissemination techniques. Though this is still an ongoing process, the resources available to the project and through the host institute have granted development in skills as to how to conduct dissemination with stakeholders and what are good practices and important learning points for future improvement.
- Presentation skills & experience: throughout the project duration, there has been a considerable number of presentations given through CHANGES activities, conference participation, external networking opportunities and host institute activities. This has allowed for further development of presentation skills and experience with a wide range of audiences and disciplines.
- Publication skills & experience: through both the project and the host institute, skills in publication of research have also been expanded. This stems from initial experience both in article writing for scientific journals, grey literature creation for public use, and book chapter writing in related disciplines.
- In terms of skills, it gave me the opportunity to research a new field and acquire experience and knowledge in its theories, approaches and methodologies.
- Moreover, working with stakeholders on the conception of an exhibition allowed me to develop project management and fundraising skills.
- The consortium environment helped me to understand the functioning of the academic world in terms of collaboration mechanisms, requirements of science practice and of European projects. The large variety of courses and training that we were offered allowed apprehending the big picture of the natural hazards and associated risks field.
- Personally, living in another country and meeting people from different countries and cultures was the most beneficial aspect of CHANGES.

7. Main results in relation to general objectives of WP6

The aim of this Work Package was to organise network wide training activities, workshops and the dissemination of project activities.
Whereas the previous 5 Work Packages focus on the CRTP, this work package is directed to network activities and includes all activities related to the organization of training courses and topical workshops, and the dissemination of the results. The training component of this network, focused on the organisation of network-wide activities in the field of training, knowledge sharing, and presentation of scientific results. Training was done in the form of intensive training courses on topics that are relevant for all of the ESR/ERs, and which often involve experts from the private companies involved as associated partners, or by inviting experts on particular topics from elsewhere. Combined with the intensive training courses, topical workshops were organized, in which also the partners and associated partners participated, to present and discuss the scientific aspects related to the various Work Packages. These topical workshops and courses were organized in the four pilot study areas.
Stakeholders from governmental organisations and private companies dealing with various aspects of risks were actively involved in the activities of the network, to guarantee user oriented development and feasible application of the results. Dissemination activities included the creation of a project website, project brochures, a DVD, and a distance education package. The website will be the host of the platform for probabilistic risk assessment, and the DSS for risk management that are developed in WPs 3/4. The training materials developed in WP5 will also be included on the website, and integrated into a distance education course on Multi-hazard risk assessment.

7.1 Task 6-1: Development of training package.

Several training materials were developed within the CHANGES project. As shown earlier in this report dissemination materials were prepared in the framework of WP4 and 5. For WP 3 training materials were made on quantitative risk assessment and on the analysis of changing risk

These deliverables were prepared by partner ITC with CNRS, UNIVIE, PLUS, TUDO, TUD. Description: Development of training package. This material was used for stakeholder preparedness, or education/teaching material for citizens.

7.2 Task 6-2: Development of the project website.

Since the start of the project a project website was established, with information on all partners, all publicly available deliverables including the probabilistic risk assessment platform, platform for risk management and risk communication platform. It will also include the training package.

Figure : Project website of the CHANGES project (http://www.changes-itn.eu/) which contains descriptions of all activities and results obtained in the project.website.

Figure : Project documents were made in different languages.

7.3 Task 6-3: Organization of session in international conferences.

By partner ITC with CNRS, UNIVIE, PLUS, TUDO, TUD. Description:organization of session related to the CHANGES project at the international EGU conference, with presentation by project partners and ESRs

- EGU 2013 : Wednesday 10 April. NH1.9, Hydro-meteorological hazards: Changing pattern of risk and effective risk mitigation strategies, 10:30–12:00, Room G9
- EGU 2014 : Monday 28 April. NH1.9, Hydro-meteorological hazards: Changing pattern of risk and effective risk mitigation strategies, 08:30–10:00, Room B5.
- EGU 2015 : Monday 13 April. NH1.9, Hydro-meteorological hazards: Changing pattern of risk and effective risk mitigation strategies, 15:30–17:00, Room G1

Figure : Project related session in EGU conferences.

7.4 Task 6-4: final conference.

The International Conference on the Analysis and Management of Changing Risk for Natural Hazards was organized to present and discuss research results in the above mentioned fields. The conference was held on 18 and 19 November, in Padua, Italy. The conference provided an opportunity to discuss multi-hazard risks and multi-disciplinary research results on the effects of changing hydro-meteorological risks and their effects on planning strategies. The conference focus was.s put both 1) on technical sessions presenting the state of the art research in the understanding of the natural processes and in the development of innovative methodologies for quantitative hazard and risk forecasts, and 2) on the practical integration of natural, engineering, economical and human sciences within multi-scale methodologies for risk management and prevention planning.

The conference represented the culmination of the EC's co-funded projects CHANGES (Changing Hydro-meteorological risks as Analysed by a New Generation of European Scientists, www.changes-itn.eu), and IncREO (Increasing Resilience through Earth Observation, www.increo-fp7.eu). The conference was supported by the following organizations:

- The European Commission, 7th framework programme, Marie Curie Actions, Copernicus programme
- The European Geophysical Union
- European Centre on Geomorphological Hazards
- European and Mediterranean Major Hazards Agreement, council of Europe
- United Nations Environmental Programme. Disasters, Environment, risk Reduction (Eco-DRR)
- United Nations Educational, Scientific and Cultural Organization. Venice Office
- International Association of Geomorphologists
- International Association for Natural Hazard Risk Management

The conference was attended by 170 participants, from 34 countries. A keynote lecture on the "Benefits and Limitations of Quantitative Risk Assessment in Dealing with Natural Hazards" was given by Dr. Suzanne Lacasse from the Norwegian Geotechnical Institute.

There were 46 oral presentations and 62 poster organized in the following scientific sessions:

- Session A: Forecasting future changes in hydro-meteorological hazards (Moderator: Mihai Micu and Jean-Philippe Malet)
- Session B: Generating of asset maps, exposure analysis and vulnerability assessment (Moderator: Alessandro Pasuto).
- Session C: Risk Management, risk communication and risk governance in a changing environment (Moderator: Karen Sudmeier-Rieux)
- Session D: Methods for modelling changing risk to hydro-meteorological hazards (Moderator: Thomas Glade).
- Session E: Earth Observation data, geo-information and visualization tools for risk assessment (Moderator: Marc Mueller).
- Session F: Joint session with UNEP: Ecosystem-based disaster risk management (Moderator: Cees van Westen)
- Session G: Joint session with IAG Working Group on Geomorphological hazards: Lessons learned and transferability of multi-hazard risk assessment methods to developing countries (Moderator: Sunil Kumar De and Mauro Soldati.)

The extended abstract of the conference are available on the following website: www.changes-itn.eu

Organizing committee:

Simone Frigerio (CNR-IRPI, Padua, Italy)
Virginia Herrera Cruz (Infoterra GmbH, Germany)
Gianluca Marcato (CNR-IRPI, Padua, Italy)
Mihai Micu (IGRAC, Romania)
Marc Mueller (Spot Image SA, France)
Alessandro Pasuto (CNR-IRPI, Padua, Italy)
Davide Poletto (UNESCO, Venice)
Jacqueline Runje (TUDO, Germany)
Luca Schenato (CNR-IRPI, Padua, Italy)
Cees van Westen (ITC/UT, Netherlands)

Programme

Tuesday 18 November

08.30 – 09.00:	Registration
09.00 – 09.10:	Opening (Marc Mueller)
09.10 – 09.30:	Keynote lecture Suzanne Lacasse (NGI)
09.30 – 10.30:	Session A: Forecasting future changes in hydro-meteorological hazards. Moderator: Mihai Micu.
10.30 – 11.00:	Coffee break
11.00 – 12.30:	Session A: Forecasting future changes in hydro-meteorological hazards. Moderator: Jean-Philippe Malet.
12.30 – 13.30:	Lunch and poster session
13.30 – 15.00:	Session B: Generating of asset maps, exposure analysis and vulnerability assessment. Moderator: Alessandro Pasuto.
15.00 – 15.30:	Coffee break
15.30 – 17.00:	Session C: Risk Management, risk communication and risk governance in a changing environment. Moderator: Stefan Greiving.
17.00 – 18.00:	Drinks and poster session

Wednesday 19 November

09.00 – 10.30 :	Session D: Methods for modelling changing risk to hydro-meteorological hazards Moderator: Thomas Glade.

10.30 – 11.00 : Coffee break
11.00 – 12.30 : Session E: Earth Observation data, geo-information and visualization tools for risk assessment.
Moderator: Marc Mueller.
12.30 – 13.30 : Lunch and poster session
13.30 – 15.00 : Session F: Joint session with UNEP: Ecosystem-based disaster risk management.
Moderator: Muralee Thummurkudy and Karen Sudmeier.
15.00 – 15.30 : Coffee break
15.30 – 16.45 : Session G: Joint session with IAG Working Group on Geomorphological hazards: Lessons learned and transferability of multi-hazard risk assessment methods to developing countries.
Moderator: Sunil Kumar De and Mauro Soldati.
16.45 – 17.15: Closing remarks (ESRs, Cees van Westen)

Thursday 20 November
Dissemination of results for the Fella study area
Date: Thursday, November 20th/2014 - 09:30/15:45
Venue: Palazzo Veneziano (Comune di Malborghetto - Valbruna, UD)
Departure by bus: 7 a.m.

7.5 Task 6-5: Professional skill courses.

See also : **http://changes-itn.eu.dnnmax.com/Training/tabid/67/Default.aspx**
The table below lists the Professional Skills courses that have been organized. The other Professional Skills courses indicated in the DoW will be organized in the second period of the project.

Code	Name	Description of contents	Partners	Time & Place
PS-01	**Research work plan development and scientific writing**	Literature review, critical reading, reviewing and summarizing publications, writing abstracts, formulating research questions, plagiarism, structuring a scientific paper, generation of illustrations).	ITC, IRM	September 2011, Poland
PS-02	**Research ethics**	Scientific attitude, professional leadership, role in civil society scientist, research collaboration, example function of scientists, cultural sensitivities and gender.	ITC	January, 2012 The Netherlands
PS-03	**Valorization of scientific results**	Societal and economic spin-off of research; examples of successful valorisation by associate partners from private sector; patents; Intellectual Property Rights; establishing an SME. Several of the partners from the private sector will be the resource persons in this course.	R&D, GEOMER AS,	June 2012, Italy
PS-04	**Dissemination of scientific results to the public**	How to communicate the results through popular publications; scientific journalism; posters with project information; press contacts; use of internet, summarizing.	TUD,	September 2012, Romania
PS-05	**Writing research grant proposals**	Finding out grant opportunities; requirements for research grants; presenting with curriculum vitae; writing personal career development plans.	TUDO	September 2012, Romania
PS-06	**Project management**	Budgeting and financial administration, planning, monitoring and evaluation. This course will be given by a senior project manager.	TUDO	April 2014, Switzerland

7.6 Task 6-6: Technical skill courses.

See also : **http://changes-itn.eu.dnnmax.com/Training/tabid/67/Default.aspx**
The table below lists the Technical Skills that have been organized. The other Technical Skills courses indicated in the DoW will be organized in the second period of the project.

Code	Name	Description of contents	Partners	Time
TS-01	**Probabilistic risk assessment**	Basics of probabilistic modelling; probability theory; uncertainty, use of historic events in stochastic modelling; probabilistic modelling for different types of hazards; expressing uncertainty of vulnerability; combining hazard and vulnerability scenarios. Maximum Probable Loss, Less Exceedance Curves. This course specifically relates to WP 1, 2 and 3.	CNR, ERN, CNRS	September 2011, Poland
TS-01B	**Multi-hazard risk assessment**	Course on the use of GIS for quantitative multi-hazard risk assessment using a case study from the Nocera area in Italy; use of Spatial Multi-Criteria evaluation for qualitative risk assessment; Decision Support Systems; Expert seminar with presentation on climate change and risk management from the Netherlands.	ITC	January 2012, Netherlands
TS-02	**Monitoring and prediction of environmental changes.**	Use of models for climate change prediction; monitoring of environmental changes, hazard processes; extraction of socio-economic parameters using multi-temporal remote sensing data combined with ancillary data; prediction of future land use changes uses modelling approaches. Course specifically relates to WP 1, and 2.	IIASA,UNIVIE, CCRM	September 2012, Romania
TS-03	**Web-GIS and Spatial Data Infrastructure**	Definition of user groups; strategic use cases for production use; testing and validation; Use of recognized open standards (both in design and documentation); open, modular, interoperable and open-source architecture; data repository and distribution requirements; definition of service types to support risk assessment applications; Open Source software tools for Web-GIS; This course specifically relates to the research of WP 3, 4 and 5.	PLUS, ITC, GEOMER	November 2012, Germany
TS-04	**Tools for risk Management**	This course presents a number of examples of the use of decision support systems, used in risk management, with emphasis on preparedness planning and early warning. This course specifically relates to WP 4 and 5	UNIL, TUD AS	June 2013, France
TS-05	**Use of risk information in Spatial Planning**	Principles of spatial planning; stakeholder analysis; Environmental Impact Assessment; Strategic Environmental Assessment; Use of Spatial Multi Criteria Evaluation. This course specifically relates to WP 2 and 4.	IRM, TUDO, R&D	September 2013: Italy

7.7 Task 6-7: Topical workshops.

See also : **http://changes-itn.eu.dnnmax.com/Training/tabid/67/Default.aspx**
The table below lists the workshops that have been organized. The other workshops inidicated in the DoW will be organized in the second period of the project.

Code	Name	Description of contents	Partners	Time
WS-01	**Risk governance implications of changing risks**	Meeting with stakeholder representatives during which they indicate the expectations of the project, and presentation of the possible implications of environmental changes to risk governance. Focusing on the relation between changes in risk governance, changes in risk management, and requirements for risk information	TUD TUDO PC-FVG	June 2012, Italy

WS-02	**Environmental changes**	During this workshop the methods for analyzing the possible impacts of climate change and environmental change are presented and discussed and their implications to hazard assessment and land use scenarios.	UNIVIE, IIASA	June 2013, France
WS-03	**Modelling changes in hazard and risk**	During this workshop the methods for probabilistic hazard and risk assessment are presented and discussed, focusing on the integration of future environmental changes and their possible impacts. The representation of uncertainty of temporal and spatial probability, as well as vulnerability is an important component of this workshop.	IGRAC ITC, CNRS,	June 2013, France
WS-04	**Changes in Risk Management**	This course presents a number of examples of the use of decision support systems, used in risk management, with emphasis on preparedness planning and early warning. This course specifically relates to WP 4 and 5	UNIL	April 2014 Switzerland
WS-05	**Web-based platform**	During this workshop the results for WP4 are presented and discussed. ESRs/ERs and partners involved in the development of the internet-based tools for risk management will present the applications for spatial planning and emergency preparedness.	PLUS, ITC, CNRS TUD	September 2013, Italy

7.8 Task 6-8: Publications.

Joint scientific publications. The target is that by month M+24 there will be at least 5 joint publications, by month M+36 at least

Below the publications of the ESRs are given. We decided not to include the publictions of the project partners themselves, but to concentrate only on those where the ESRs are (co)authors.

See: **http://www.changes-itn.eu/People/tabid/64/Default.aspx**

ESR1

- Breinl, K., Turkington, T., Stowasser, M. (2013). Stochastic generation of multi-site daily precipitation for applications in risk management. In: Journal of Hydrology, 498, 2013 http://dx.doi.org/10.1016/j.jhydrol.2013.06.015
- Breinl, K., Turkington, T., Stowasser, M. (2014). A weather generator for hydro-meteorological hazard applications. In: Geophysical Research Abstracts Vol. 16, EGU2014-10522.
- Breinl, K., Turkington, T., Stowasser, M. (2014). Simulating daily precipitation and temperature: a weather generation framework for assessing hydrometeorological hazards. In: Meteorological Applications, n/a. http://onlinelibrary.wiley.com/doi/10.1002/met.1459/abstract
- Kosanic, A., Harrison, S., Anderson, K., Turkington, T. (2014) Present and Historical Climate Variability and its Ecological Impact on Vegetation in South West England. In: Geophysical Research Abstracts Vol. 16.
- Turkington, T., Breinl, K., Ettema, J. , van Westen, C.J.(2014), The impact of climate change on causal flood types in two European Alpine catchments. In:Geophysical Research Abstracts Vol. 16, EGU2014-10775.
- Turkington, T., Breinl, K., van Westen, C.J., Malet-J.-P., Ettema, J. (2013). Analysing the problems involved in assessing hydro - meteorological triggers : abstract. In: Geophysical Research Abstracts, vol. 15, EGU2013-1678
- Turkington, T., Ettema, J., and van Westen C.J. (2013) Linking meteorological conditions to flood and flash flood occurrence - why is it so difficult? abstract for the 7th European Conference on Severe Storms, Helsinki, Finland
- Turkington, T., Ettema, J., van Westen, C. J., and Breinl, K. (2014) Empirical atmospheric thresholds for debris flows and flash floods in the Southern French Alps, Nat. Hazards Earth Syst. Sci., 14, 1517-1530, 2014 doi:10.5194/nhess-14-1517-2014 http://www.nat-hazards-earth-syst-sci.net/14/1517/2014/
- Turkington, T., van Westen, C., Ettema, J. (2012), The challenges of identifying and analyzing triggering rainfall amounts for floods and landslides in Europe as part of the CHANGES project. Poster presentation at VALUE End User Conference, Kiel

- Wood, J.L., Turkington, T, Harrison, S.H. and Reinhardt, L. (2013) Mass Movement Inventories for Climate Research in the European Alps. Poster at: AGU Fall Meeting 2013, 9-13 December 2013, San Fransisco, United States of America, NH21A-1508

ESR2

- Breinl, K. (2012). Pluvial and fluvial flooding: integration in probabilistic flood hazard assessment using a coupled rainfall-discharge generator. In: Geophysical Research Abstracts Vol. 14, EGU2012-1990-1.
- Breinl, K. (2014). Integrated assessment of fluvial and pluvial flood hazards in the city of Salzburg, Austria. In: Geophysical Research Abstracts Vol. 16, EGU2014-12960.
- Breinl, K., Turkington, T., Stowasser, M. (2013). Stochastic generation of multi-site daily precipitation for applications in risk management. In: Journal of Hydrology, 498, 2013 http://dx.doi.org/10.1016/j.jhydrol.2013.06.015
- Breinl, K., Turkington, T., Stowasser, M. (2014). A weather generator for hydro-meteorological hazard applications. In: Geophysical Research Abstracts Vol. 16, EGU2014-10522.
- Breinl, K., Turkington, T., Stowasser, M. (2014). Simulating daily precipitation and temperature: a weather generation framework for assessing hydrometeorological hazards. In: Meteorological Applications, n/a. http://onlinelibrary.wiley.com/doi/10.1002/met.1459/abstract
- Turkington, T., Breinl, K., Ettema, J. , van Westen, C.J.(2014), The impact of climate change on causal flood types in two European Alpine catchments. In:Geophysical Research Abstracts Vol. 16, EGU2014-10775.
- Turkington, T., Breinl, K., van Westen, C.J., Malet-J.-P., Ettema, J. (2013). Analysing the problems involved in assessing hydro - meteorological triggers : abstract. In: Geophysical Research Abstracts, vol. 15, EGU2013-1678
- Turkington, T., Ettema, J., van Westen, C. J., and Breinl, K. (2014) Empirical atmospheric thresholds for debris flows and flash floods in the Southern French Alps, Nat. Hazards Earth Syst. Sci., 14, 1517-1530, 2014 doi:10.5194/nhess-14-1517-2014 http://www.nat-hazards-earth-syst-sci.net/14/1517/2014/
- Zumpano, V., Hussin, H.Y., Breinl, K. (2012). Exploring probabilistic tools for the development of a platform for Quantitative Risk Assessment (QRA) of hydro-meteorological hazards in Europe. In: Geophysical Research Abstracts Vol. 14, EGU2012-13467-1

ESR3

- Schlögel R., Braun A., Torgoev A., Fernandez-Steeger T. M. & Havenith H-B. (2013). Assessment of Landslides Activity in Maily-Say Valley, Kyrgyz Tien Shan. In: Landslide Science and Practice (Vol. 1): Landslide Inventory and Susceptibility and Hazard Zoning Margottini, Claudio; Canuti, Paolo; Sassa, Kyoji (Eds.) pp 111-117
- Schlögel R., Doubre C., Malet J.-P. (2013). Creation of multi-temporal landslide inventories from the analysis of series of optical images: the case of the Ubaye Valley, South French Alps. Poster session presented at: JAG-2013, September 17-18, Grenoble, France.
- Schlögel R., Doubre C., Malet J.-P., Lebourg T. (2013). ALOS/PALSAR DInSAR processing for the monitoring of landslide displacements: an experiment in the South French Alps. Oral presentation at: JAG-2013, September 17-18, Grenoble, France.
- Schlögel R., Torgoev I., De Marneffe C. & Havenith H.B. (2011) Evidence of a changing size-frequency distribution of landslides in the Kyrgyz Tien Shan, Central Asia. Earth surface processes and landforms 36 (12), 1658–1669. DOI: 10,1002/esp.2184
- Schlögel, R., Doubre, C., Malet, J.-P. (2014). Monitoring the kinematic of active landslides with ALOS/PALSAR DInSAR processing. Oral presentation at: EGU-2014, April 30- May 3, Wien, Austria.
- Schlögel, R., Doubre, C., Malet, J.-P., Lebourg T. (2014). Kinematic of Deep-seated La Clapière Landslide (Tinée Valley, French Alps) monitored by DInSAR and ground-based measurements. Oral presentation at: 2nd Slope Tectonic Conference, November 9, 2014, Trondheim, Norway.
- Schlögel, R., Doubre, C., Malet, J.-P., Masson, F. (2015). Landslide deformation monitoring with ALOS/PALSAR imagery: a D-InSAR geormorphological interpretation method. Geomorphology, 231, 314-330. doi:10.1016/j.geomorph.2014.11.031
- Schlögel, R., Malet, J.-P. , Reichenbach, P., Remaître, A. (2014). Landslide magnitude and temporal occurrence in the Ubaye Valley from the analysis of a multi-date inventory. Oral

presentation at: ￼￼Analysis and Management of Changing Risks for Natural Hazards November 18-19, 2014, Padua, Italy.

- Schlögel, R., Malet, J.-P., Doubre C., Lebourg. T. (2014). Structural control on the dynamics of the deep-sea- ted La Clapière Landslide (Tinée Valley, French Alps) from DInSAR and ground-based observa- tions. Poster session presented at: Analysis and Management of Changing Risks for Natural International conference, November 18-19, 2014, Padua, Italy.
- Schlögel, R., Malet, J.-P., Doubre, C., Reichenbach, P. (2014). Assessment of Landslides Activity using multi-source data: the case of the Ubaye Valley, South French Alps. Poster session presented at: 17th Joint Geomorphological Meeting, June 30-July 1, 2014, Liège, Belgium.

ESR4

- Malek Ž (2014), Combining participatory modelling and land change simulation for generating spatially explicit scenarios of future tourism development: example in the Italian Alps. International Scientific Committee on Research in the Alps (ISCAR) Forum Alpinum '14. Darfo Boario Terme, Italy http://www.forumalpinum.org/en/programme/overview/

- Malek Ž (2015), Fuzzy-logic Cognitive Mapping: Introduction and overview of the method. In: Gray S, Jordan R, Pallisimio M, Gray S. Including Stakeholders in Environmental Modeling: Considerations, Methods and Applications (In press).
- Malek Ž, (2014), Future land change scenarios for risk assessment: Linking participatory modelling and geosimulation. International Conference: Analysis and Management of Changing Risks for Natural Hazards. Padova, Italy http://www.changes-itn.eu/Portals/0/Content/2014/Final%20conference/abstracts/BO4_Abstract_Malek.pdf
- Malek Ž, Balteanu D, Micu M (2014), Land use and Cover Changes in the Bend Carpathians and Subcarpathians. International Geographical Union - Commission on Land Use and Cover Changes 2014 Symposium: Land use-Land cover Changes and Land Degradation, Bucharest, Romania
- Malek Ž, Boerboom L (2015), Development of land use change scenarios to address changes to hydro-meteorological risk: an Alpine case study. Accepted to Mountain Research and Development.
- Malek Ž, Glade T, Boerboom L (2014). Generating local scale land use/cover change scenarios: case studies of high-risk mountain areas. Geophysical Research Abstracts Vol. 16, EGU2014-5675, 2014 http://meetingorganizer.copernicus.org/EGU2014/EGU2014-5675.pdf
- Malek Ž, Glade T, Boerboom L (under review), Future forest cover change under a set of forest policy scenarios: An example from Buzau Subcarpathians, Romania. Submitted to Environmental Management.
- Malek Ž, Schröter D , Glade T (2013), Land use/cover changes in European mountain areas: identifying links between global driving forces and local consequences. Geophysical Research Abstracts Vol. 15, EGU2013-1900-1, 2013 http://meetingorganizer.copernicus.org/EGU2013/EGU2013-1900-1.pdf
- Malek Ž, Schröter D, Glade T, Boerboom L (2014). Effects of possible forest management scenarios in the Romanian Carpathians. Abstract for the 2nd Global Land Project Open Science Meeting. Berlin 2014.
- Malek Ž, Schröter D, Glade T, Boerboom L (2014). Hydro-meteorological risk and socio-economic development: future land cover scenarios of an alpine valley. Abstract for the 2nd Global Land Project Open Science Meeting. Berlin 2014.

ESR5

- Ciurean R. L. and Glade T. (2012) Uncertainty analysis in vulnerability estimations for elements at risk – a review of concepts and some examples on landslides, Geophysical Research Abstracts, Vol. 14, EGU2012-12561 http://meetingorganizer.copernicus.org/EGU2012/EGU2012-12561.pdf
- Ciurean R. L., Schröter D. and Glade T. (2013) Conceptual Frameworks of Vulnerability Assessments for Natural Disasters Reduction, Approaches to Disaster Management - Examining the Implications of Hazards, Emergencies and Disasters, Prof. John Tiefenbacher (Ed.), ISBN: 978-953-51-1093-4, InTech, DOI: 10.5772/55538. Available from: http://www.intechopen.com/books/approaches-to-disaster-management-examining-the-implications-of-hazards-emergencies-and-disasters/conceptual-frameworks-of-vulnerability-assessments-for-natural-disasters-reduction

- Ciurean R.L, Chen L., Hussin H., van Westen C., Glade T., Frigerio S., Pasuto A. (2014) Quantitative vulnerability assessment of buildings to debris-flows in Fella River Basin using run-out modeling and damage data from the 29th of August 2003 event http://www.changes-itn.eu/Portals/0/Content/2014/Final%20conference/abstracts/BO3_Abstract_Ciurean_et_al.pdf
- Ciurean R.L., Hussin H.Y., Frigerio S., Glade T. (2013) Probabilistic modeling of uncertainties in vulnerability assessment - application to hydro-meteorological hazards in the municipality of Malborghetto-Valbruna, Italy, 8th IAG International Conference on Geomorphology - August 27th to 31st, 2013 http://www.geomorphology-iag-paris2013.com/en/detailed-programme
- Ciurean R.L., Zumpano V., Micu M., and Glade T. (2014) A regional scale landslide vulnerability assessment using First Order Second Moment approach: a case study in Buzău County, Romania. In: Geophysical Research Abstracts Vol. 16, EGU2014-13346 http://meetingorganizer.copernicus.org/EGU2014/EGU2014-13346-1.pdf
- Eidsvig U., McLean A., Vangelsten B. V., Kalsnes B., Ciurean R. L., Argyroudis S., Winter M., Mavrouli O. C., Fotopoulou S., Pitilakis K., Baills A., Malet J. P., Kaiser G. (2014) Assessment of socioeconomic vulnerability to landslides using an indicator-based approach: methodology and case studies, Bull. Eng. Geol. Environ., 73 (2), pp 307 - 324 http://link.springer.com/article/10.1007/s10064-014-0571-2

- Godfrey A., Ciurean R.L., van Westen C.J., Kingma N.C., and Glade T. (2014) Assessing vulnerability of buildings to hydro-meteorological hazards using an expert based approach – an application in the Nehoiu Valley, Romania (paper in review), International Journal of Disaster Risk Reduction
- Hussin H.Y., Ciurean R., Frigerio S., Marcato G., Calligaris C., Reichenbach P., Van Westen C.J. and Glade T. (2014) Assessing the effect of mitigation measures on landslide hazard using 2D numerical runout modelling. In: Sassa K., Canuti P., Yin Y., (eds.). Landslide Science for a Safer Geoenvironment: Springer International Publishing, pp. 679-684. http://link.springer.com/chapter/10.1007%2F978-3-319-05050-8_105
- Jaedicke C., Van Den Eeckhaut M., Nadim F., Hervas J., Kalsnes B., Vangelsten B.V., Smith J.T., Tofani V., Ciurean R.L., Winter M.G., Sverdrup-Thygeson K., Syre E., Smebye H. (2014) Identification of landslide hazard and risk 'hotspots' in Europe, Bull. Eng. Geol. Environ., 73 (2), pp 325 - 339 http://link.springer.com/article/10.1007%2Fs10064-013-0541-0
- Papathoma-Köhle M. and Ciurean R. L. (2014) Integrating physical vulnerability models in a holistic framework-a tool for practitioners. In: Geophysical Research Abstracts Vol. 16, EGU2014-3468 **http://meetingorganizer.copernicus.org/EGU2014/EGU2014-3468.pdf**

ESR6

- Ciurean R.L, Chen L., Hussin H., van Westen C., Glade T., Frigerio S., Pasuto A. (2014) Quantitative vulnerability assessment of buildings to debris-flows in Fella River Basin using run-out modeling and damage data from the 29th of August 2003 event http://www.changes-itn.eu/Portals/0/Content/2014/Final%20conference/abstracts/BO3_Abstract_Ciurean_et_al.pdf
- Ciurean R.L., Hussin H.Y., Frigerio S., Glade T. (2013) Probabilistic modeling of uncertainties in vulnerability assessment - application to hydro-meteorological hazards in the municipality of Malborghetto-Valbruna, Italy, 8th IAG International Conference on Geomorphology - August 27th to 31st, 2013 http://www.geomorphology-iag-paris2013.com/en/detailed-programme
- Hussin H.Y., Ciurean R., Frigerio S., Marcato G., Calligaris C., Reichenbach P., Van Westen C.J. and Glade T. (2014) Assessing the effect of mitigation measures on landslide hazard using 2D numerical runout modelling. In: Sassa K., Canuti P., Yin Y., (eds.). Landslide Science for a Safer Geoenvironment: Springer International Publishing, pp. 679-684. http://link.springer.com/chapter/10.1007%2F978-3-319-05050-8_105
- Hussin, H.Y., Quan Luna, B., van Westen, C.J., Christen, M., Malet, J.-P. and van Asch, Th.W.J. (2012). Assessing the debris flow run-out frequency of a catchment in the French Alps using a parameterization analysis with the RAMMS numerical run-out model. In: Geophysical Research Abstracts Vol. 14, EGU2012-12593 http://meetingorganizer.copernicus.org/EGU2012/EGU2012-12593.pdf
- Hussin, H.Y., van Westen, C.J. and Reichenbach, P. (2013). Methodological framework for the probabilistic risk assessment of multi-hazards at a municipal scale: a case study in the Fella river valley, Eastern Italian Alps. In: Geophysical Research Abstracts Vol. 15, EGU2013-13584 http://meetingorganizer.copernicus.org/EGU2013/EGU2013-13584.pdf

- Hussin, H.Y., Zumpano, V., Sterlacchini, S., Reichenbach, P., Bãlteanu, D., Micu, M., Bordogna, G., Cugini, M. (2013). Comparing the predictive capability of landslide susceptibility models in three different study areas using the Weights of Evidence technique. In: Geophysical Research Abstracts Vol. 15, EGU2013-12701-1 http://meetingorganizer.copernicus.org/EGU2013/EGU2013-12701-1.pdf
- Hussin,H.Y., Quan Luna,B.van Westen,C.J., Christen,M., Malet,J.-P. and van Asch, Th. W. J. (2012) Parameterization of a numerical 2-D debris flow model with entrainment: a case study of the Faucon catchment, Southern French Alps. Nat. Hazards Earth Syst. Sci., 12, 3075-3090 http://www.nat-hazards-earth-syst-sci.net/12/3075/2012/nhess-12-3075-2012.pdf
- Zumpano, V., Hussin, H. Y., Reichenbach, P., Balteanu, D., Micu, M. and Sterlacchini, S.,(2014). A landslide susceptibility analysis for Buzău County, Romania, Rom. J. Geogr. Roum. Geogr., 58(1), 9–16 http://www.rjgeo.ro/atasuri/RR%20Geographie%2058_1/Zumpano%20et%20al..pdf
- Zumpano, V., Hussin, H.Y., Breinl, K. (2012). Exploring probabilistic tools for the development of a platform for Quantitative Risk Assessment (QRA) of hydro-meteorological hazards in Europe. In: Geophysical Research Abstracts Vol. 14, EGU2012-13467-1

ESR 7

- Aucelli P. P. C., Balteanu Dan, Pisano L., Rosskopf C. M., and Zumpano V. (2014). A methodological approach for landslide economic damage estimation in rural contexts. In: Geophysical Research Abstracts Vol. 16, EGU2014-14418, 2014
- Ciurean R.L., Zumpano V., Micu M., and Glade T. (2014) A regional scale landslide vulnerability assessment using First Order Second Moment approach: a case study in Buzău County, Romania. In: Geophysical Research Abstracts Vol. 16, EGU2014-13346 http://meetingorganizer.copernicus.org/EGU2014/EGU2014-13346-1.pdf
- Damen, M. Micu, M. , Zumpano, V., Van Westen, C.J., Sijmons, K. and Balteanu, D(2014).Landslide mapping and interpretation: implications for landslide susceptibility analysis in discontinuous data environment Conference proceedings International Conference Analysis and Management of Changing Risks for Natural Hazards 18-19 November 2014 I Padua, Italy.
- Hussin, H.Y., Zumpano, V., Sterlacchini, S., Reichenbach, P., Bãlteanu, D., Micu, M., Bordogna, G., Cugini, M. (2013). Comparing the predictive capability of landslide susceptibility models in three different study areas using the Weights of Evidence technique. In: Geophysical Research Abstracts Vol. 15, EGU2013-12701-1 http://meetingorganizer.copernicus.org/EGU2013/EGU2013-12701-1.pdf
- Malek Ž, Zumpano V, Schröter D, Glade T, Balteanu D, Micu M (2014). Scenarios of land cover change and landslide susceptibility: an example from the Buzau Subcarpathians, Romania. Conference proceeding. IAEG 2014 XII Congress, Torino, Italy http://link.springer.com/chapter/10.1007/978-3-319-09048-1_144#page-1
- Micu M., Jurchescu M, Micu D. , Bălteanu D., Zumpano V., Zarea R., Leau L. (2013) The morphogenesis of deep-seated landslides in the Romanian Curvature Carpathians as a proxy in regional landslide hazard assessment, 8th IAG International Conference on Geomorphology - August 27th to 31st, 2013
- Micu, M., Jurchescu, M., Micu, D., Zarea, R., Zumpano, V. and Bălteanu, D.,(2014). A morphogenetic insight into a multi-hazard analysis: Bâsca Mare landslide dam, Landslides, 11(6), 1131–1139 http://link.springer.com/article/10.1007%2Fs10346-014-0519-4#page-1
- Zumpano V, Malek Ž (2014), The consequences of forest management in the Curvature Carpathians: Analysing the relation between forest cover change and landslide susceptibility in Buzau County, Romania. International Geographical Union - Commission on Land Use and Cover Changes 2014 Symposium: Land use-Land cover Changes and Land Degradation, Bucharest, Romania
- Zumpano V, Malek Ž, Micu M, Reichenbach P, Balteanu D (2014), Urban area exposure to landslides under landuse changes scenarios: application in a discontinuous data environment. International Conference: Analysis and Management of Changing Risks for Natural Hazards. Padova, Italy http://www.changes-itn.eu/Portals/0/Content/2014/Final%20conference/abstracts/BO5_Abstract_Zumpano_%20et_%20al.pdf
- Zumpano V., Balteanu D., Mazzorana B., and Micu M. (2014), Using Formative Scenario Analysis approach for landslide risk analysis in a relatively scarce data environment: preliminary results. In Geophysical Research Abstracts Vol. 16, EGU2014- 14576 **http://meetingorganizer.copernicus.org/EGU2014/EGU2014-14576-1.pdf**

ESR8

- Prenger-Berninghoff, K. (2012), Adapting to climate change: the need for EU Cohesion Policy to adjust funding. July 11-15, AESOP 2012, Ankara, Turkey.
- Prenger-Berninghoff, K. (2012), Regional vulnerability to climate change and the role of cohesion policy in climate change adaptation. Abstract for FLOODrisk 2012, 20-22 November, Rotterdam, The Netherlands.
- Prenger-Berninghoff, K., Cortes, V. J., Sprague, T., Aye,Z. C., Greiving. S., Głowacki, W., and Sterlacchini, S. (2014), The connection between long-term and short-term risk management strategies for flood and landslide hazards: examples from land-use planning and emergency management in four European case studies, Nat. Hazards Earth Syst. Sci., 14, 3261-3278, doi:10.5194/nhess-14-3261-2014. http://www.nat-hazards-earth-syst-sci.net/14/3261/2014/nhess-14-3261-2014.html
- Prenger-Berninghoff, K., Cortes, V.J., Aye, Z.C., Sprague, T. (2013), Coordination of short-term and long-term mitigation measures of hydro-meteorological risks: the importance of establishing a link between emergency management and spatial planning. In: Geophysical Research Abstracts Vol. 15, EGU2013-5445-1 http://meetingorganizer.copernicus.org/EGU2013/EGU2013-5445-1.pdf

- Prenger-Berninghoff, K., Głowacki, W., Komenda, J., Leroi, E. (2014), The impact of the EU Flood Risk Directive on spatial planning using examples from French and Polish case study sites. International Conference Analysis and Management of changing risks for natural hazards. 18-19 November 2014. Padova, Italy.
- Prenger-Berninghoff, K., Głowacki, W., Komenda, J., Sprague, T. (2013), The legal basis for dealing with natural hazards in spatial planning in different EU countries. July 15-19, AESOP 2013, Dublin, Ireland.
- Prenger-Berninghoff, K., Greiving, S. (2014), The use of risk information in spatial planning in Europe: examples from case study sites in Italy and Romania with a focus on flood and landslide hazards. In: Lollino, G., Manconi, A., Guzzetti, F., Culshaw, M., Bobrowsky, P., Luino, F. (eds.) (2014): Engineering Geology for Society and Territory - Volume 5, Springer International Publishing, pp 737-741. http://link.springer.com/chapter/10.1007%2F978-3-319-09048-1_143
- Sprague, T., Prenger-Berninghoff, K., and Charrière, M. (2013), Risk Communication: the connection between assessment and management of changing risks. In: Geophysical Research Abstracts Vol. 15, EGU2013-1

ESR9

- Aye, Z.C., Jaboyedoff, M., Derron, M-H. (2012). An Integrated Web-based Decision Support System in Disaster Risk Management. EGU 2012, 22-27 April, Vienna, Austria.
- Aye, Z.C., Jaboyedoff, M., Derron, M-H. (2012). Development of A Web-based Decision Support System (DSS) for the use of risk information in risk reduction. FLOODrisk 2012, 20-22 November, Rotterdam, The Netherlands.
- Aye, Z.C., Jaboyedoff, M., Derron, M-H. (2013). Application of a web-based Decision Support System in risk management. EGU 2013, 7-12 April, Vienna, Austria.
- Aye, Z.C., Jaboyedoff, M., Derron, M-H., van Westen, C.J (2014). Prototype of a web-based participative decision support platform in natural hazards and risk management (subm). ISPRS International Journal of Geo-information.
- Aye, Z.C., Olyazadeh, R., Jaboyedoff, M., Derron, M-H. (2014). Prototype development of a web-based participative decision support platform in risk management. EGU 2014, 27-2 May, Vienna, Austria.
- Jaboyedoff, M.,Aye, Z., Derron, M.H., Nicolet, P. and Olyazadeh, R., Using the consequence – frequency matrix to reduce the risk: examples and teaching, CHANGES,Padova, November 2014 http://www.changes-itn.eu/Portals/0/Content/2014/Final%20conference/abstracts/CO1_Abstract_Jaboyedoff_et_al.pdf
- Prenger-Berninghoff, K., Cortes, V. J., Sprague, T., Aye,Z. C., Greiving. S., Głowacki, W., and Sterlacchini, S. (2014), The connection between long-term and short-term risk management strategies for flood and landslide hazards: examples from land-use planning and emergency management in four European case studies, Nat. Hazards Earth Syst. Sci., 14, 3261-3278,

doi:10.5194/nhess-14-3261-2014. http://www.nat-hazards-earth-syst-sci.net/14/3261/2014/nhess-14-3261-2014.html

- Prenger-Berninghoff, K., Cortes, V.J., Aye, Z.C., Sprague, T. (2013), Coordination of short-term and long-term mitigation measures of hydro-meteorological risks: the importance of establishing a link between emergency management and spatial planning. In: Geophysical Research Abstracts Vol. 15, EGU2013-5445-1 http://meetingorganizer.copernicus.org/EGU2013/EGU2013-5445-1.pdf
- Roya Olyazadeh , Cees van Westen , Wim H Bakker , Zar Chi Aye , Michel Jaboyedoff , and Marc-Henri Derron , (April 2014) Multi-Criteria Decision Making for a Spatial Decision Support System on the Analysis of Changing Risk, EGU 2014 Vienna,Austria
- Roya Olyazadeh; Zar Chi Aye; Michel Jaboyedoff;(2013)Development of a prototype for spatial decision support system in risk reduction based on open-source web-based platform,November 2013 Castellon,Spain http://geomundus.org/images/anopensourcewebbasedsdssunil.pdf

ESR10

- Almoradie, A., Cortes, V.J., Jonoski, A. (2013), Web-based stakeholder collaboration in flood risk management. Journal of Flood Risk Management. DOI: 10.1111/jfr3.12076.
- Cortes Arevalo, V. J., Charriere, M., Bossi, G., Frigerio, S., Schenato, L., Bogaard, T., Bianchizza, C., Pasuto, A., and Sterlacchini, S.: Evaluating data quality collected by volunteers for first-level inspection of hydraulic structures in mountain catchments, Nat.Hazards Earth Syst. Sci., 14, 2681-2698, doi:10.5194/nhess-14-2681-2014, 2014. http://www.nat-hazards-earth-syst-sci.net/14/2681/2014/nhess-14-2681-2014.html
- Cortes, J. T. Sprague, S. Frigerio, T. Bogaard, S. Sterlacchini. (2014) The role of community knowledge and participation for hydraulic-structure inspections: Combining knowledge with action trough citizen-science projects. International Conference Analysis and Management of changing risks for natural hazards. 18-19 November 2014. Padova, Italy.
- Cortes, V.J., Frigerio, S., Schenato, L., Pasuto, A & Sterlacchini. S. (2013), Review of the current risk management strategies in Europe for hydro-meteorological hazards at protection and emergency level.Comprehensive Flood Risk Management – Klijn & Schweckendiek (eds). 2013 Taylor & Francis Group, London, ISBN 978-0-415-62144-1.
- Cortes, V.J., Frigerio, S., Schenato, L., Sterlacchini, S., Bogaard, T., and Pasuto, A (2014), Setting priorities for management of hydraulic structures in mountain catchments. HIC 2014 – 11th International Conference on Hydroinformatics "Informatics and the Environment: Data and Model Integration in a Heterogeneous Hydro World" New York, USA August 17 – 21, 2014.
- Cortes, V.J., Sterlacchini, S., Bogaard, T., Frigerio, S., Schenato, L., and Pasuto, A. (2014), Decision support methodology to establish priorities on the inspection of structures. Geophysical Research Abstracts Vol. 16, EGU2014-4189-3, 2014 EGU General Assembly 2014.
- Cortes,V.J., Charrière, M., Aye, Z.C., Bossi, G., Viero, A., Frigerio, S., Schenato, L., Sterlacchini, S., Bogaard, T. & Pasuto, A. (2013), First level inspection by trained-volunteers of torrent control structures in mountainous catchments: Towards a quality-evaluation of data collected. Geophysical Research Abstracts Vol. 15, EGU2013-4854-1, 2013. EGU General Assembly 2013. Poster presentation.
- M. Evers, A. Jonoski, C. Maksimovic, L. Lange, S. Ochoa Rodriguez, A. Teklesadik, J. Cortes Arevalo, A. Almoradie, N. Eduardo Simoes, L.Wang, C. Makropoulos (2012), Collaborative modelling for active involvement of stakeholders in urban flood risk management http://www.nat-hazards-earth-syst-sci.net/12/2821/2012/nhess-12-2821-2012.pdf
- Prenger-Berninghoff, K., Cortes, V. J., Sprague, T., Aye,Z. C., Greiving. S., Głowacki, W., and Sterlacchini, S. (2014), The connection between long-term and short-term risk management strategies for flood and landslide hazards: examples from land-use planning and emergency management in four European case studies, Nat. Hazards Earth Syst. Sci., 14, 3261-3278, doi:10.5194/nhess-14-3261-2014. http://www.nat-hazards-earth-syst-sci.net/14/3261/2014/nhess-14-3261-2014.html
- Prenger-Berninghoff, K., Cortes, V.J., Aye, Z.C., Sprague, T. (2013), Coordination of short-term and long-term mitigation measures of hydro-meteorological risks: the importance of establishing a link between emergency management and spatial planning. In: Geophysical Research Abstracts Vol. 15, EGU2013-5445-1 http://meetingorganizer.copernicus.org/EGU2013/EGU2013-5445-1.pdf

ESR11

- Charriere, M.K.M., Sprague, T., Bogaard, T.A, Greiving, S., Malet, J.-P., Mostert, E. (2013). Are managers' and the general public's perceptions of risk communication needs in line? A French alpine valley case study. Geophysical Research Abstracts Vol. 15, EGU2013-3173-2, EGU General Assembly 2013. Oral presentation
- Cortes, J. T. Sprague, S. Frigerio, T. Bogaard, S. Sterlacchini. (2014) The role of community knowledge and participation for hydraulic-structure inspections: Combining knowledge with action trough citizen-science projects. International Conference Analysis and Management of changing risks for natural hazards. 18-19 November 2014. Padova, Italy.
- Greiving, S., Schmidt-Thomé , P., Davoudi, S., Peltonen, L. and Sprague, T. (2012)Implications for territorial development and challenges for the territorial cohesion of the EC. In: P. Schmidt-Thomé and S. Greiving, eds., in European climate vulnerabilities and adaptation: A spatial planning perspective. Wiley & Blackwell.
- Prenger-Berninghoff, K., Cortes, V. J., Sprague, T., Aye,Z. C., Greiving. S., Głowacki, W., and Sterlacchini, S. (2014), The connection between long-term and short-term risk management strategies for flood and landslide hazards: examples from land-use planning and emergency management in four European case studies, Nat. Hazards Earth Syst. Sci., 14, 3261-3278, doi:10.5194/nhess-14-3261-2014. http://www.nat-hazards-earth-syst-sci.net/14/3261/2014/nhess-14-3261-2014.html
- Prenger-Berninghoff, K., Cortes, V.J., Aye, Z.C., Sprague, T. (2013), Coordination of short-term and long-term mitigation measures of hydro-meteorological risks: the importance of establishing a link between emergency management and spatial planning. In: Geophysical Research Abstracts Vol. 15, EGU2013-5445-1 http://meetingorganizer.copernicus.org/EGU2013/EGU2013-5445-1.pdf
- Prenger-Berninghoff, K., Głowacki, W., Komenda, J., Sprague, T. (2013), The legal basis for dealing with natural hazards in spatial planning in different EU countries. July 15-19, AESOP 2013, Dublin, Ireland.
- Sprague, T. 2012. Comparing political frameworks: what lessons can China's South-North Water Diversion learn from Spain's Ebro Water Transfer? August 26-30, 32nd International Geographical Congress (IGC 2012), Cologne, Germany.
- Sprague, T. and Greiving, S. (2012). Flood Risk Management Strategies:A comparative analysis of different EU countries. FLOODrisk 2012, November 20-22, Rotterdam,
- Sprague, T., Greiving, S., Schmidt-Thomé, P., Davoudi, S. and S. Juhola. 2012. Policy Implications for the ESPON Climate Project Vulnerability Assessment. July 11-15, AESOP 2012, Ankara, Turkey.
- Sprague, T., Prenger-Berninghoff, K., and Charrière, M. (2013), Risk Communication: the connection between assessment and management of changing risks. In: Geophysical Research Abstracts Vol. 15, EGU2013-1206 http://meetingorganizer.copernicus.org/EGU2013/EGU2013-1206.pdf

ESR12

- Charrière, M., Bogaard, T., and Mostert, E. (2014). Communicators' perspective on snow avalanche risk communication. American Geophysical Union Fall Meeting, December 15-19, San Francisco. Poster Presentation.
- Charrière, M., Bogaard, T., Junier, S.J., Malet, J.P., and Mostert, E. (2014). One exhibition, many goals. A case study on how to combine scientific questions with stakeholder views on effective communication of risks. American Geophysical Union Fall Meeting, December 15-19, San Francisco. Poster Presentation.
- Charrière, M., Bogaard, T., Junier, S.J., Malet, J.P., and Mostert, E. (2014). Testing the impact on natural risks' awareness of visual communication through an exhibition. 23rd SRA-E Conference, June 16-18, Istanbul. Oral Presentation.
- Charrière, M., Bogaard, T., Junier, S.J., Malet, J.P., and Mostert, E. (2014). Testing the impact on natural risks' awareness of visual communication through an exhibition. European Geosciences Union, General Assembly 2014, April 27 – Mai 02, Vienna. Poster presentation.
- Charrière, M., Bogaard, T., Mostert, E. (2013) Disaster managers' perception of effective visual risk communication for general public. In: Proceedings of the 8th International Conference on Geo-Information for Disaster Management, 13-14 December 2012, Enschede, The Netherlands. http://www.changes-itn.eu/

- Charriere, M.K.M., Bogaard, T.A, Malet, J.-P., Mostert, E. (2013) Increasing awareness and preparedness by an exhibition and studying the effect of visuals. Geophysical Research Abstracts Vol. 15, EGU2013-5060, EGU General Assembly 2013. Poster Presentation.
- Charriere, M.K.M., Junier, S.J., Mostert, E., Bogaard, T.A. (2012) Flood risk communication - Visualization tools and evaluations of effectiveness. FLOODrisk 2012, 20-22 November, Rotterdam, The Netherlands. Oral Presentation
- Charriere, M.K.M., Junier, S.J., Mostert, E., Bogaard, T.A. (2013) Flood risk communication - Visualization tools and evaluations of effectiveness. Flood Risk Management – Klijn & Schweckendiek (eds). 2013 Taylor & Francis Group, London, ISBN 978-0-415-62144-1.
- Charrière, M.K.M., Junier, S.J., Mostert, T.A., Bogaard, E., Mostert, and J.-P., Malet. (2014) Testing the effectiveness of visual risk communication in reality. A research approach that is beneficial for both scientists and communities at risk. International Conference Analysis and Management of Changing Risks for Natural Hazards, 18-19 November 2014, Padova, Italy.
- Charriere, M.K.M., Sprague, T., Bogaard, T.A, Greiving, S., Malet, J.-P., Mostert, E. (2013). Are managers' and the general public's perceptions of risk communication needs in line? A French alpine valley case study. Geophysical Research Abstracts Vol. 15, EGU2013-3173-2, EGU General Assembly 2013. Oral presentation

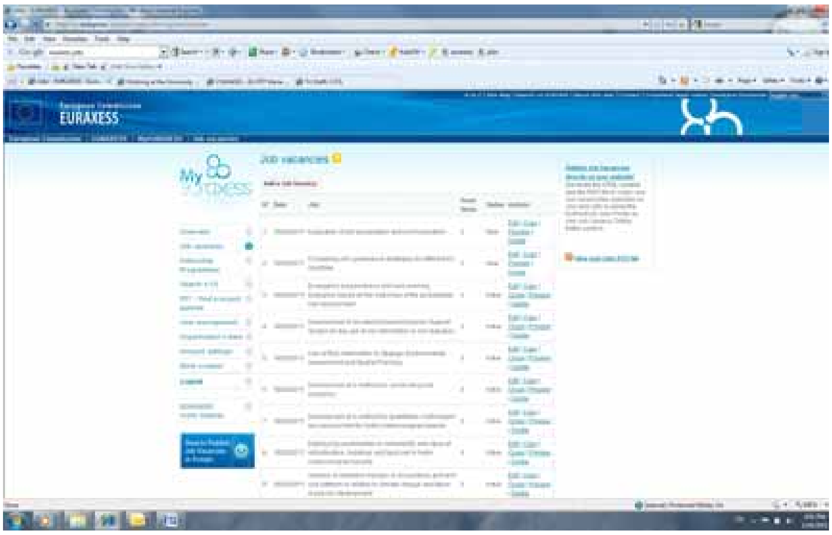
8. Main results in relation to general objectives of WP7

The aim of this Work Package is to ensure the coordination and management of the network the planning of the network activities, support in acquisitions of ESRs and ERs, and organisation of network meetings. This work package is directed to network activities and includes all activities related to Network Coordination and management. The Network coordination activities include the organization of the network, contact with the EU representative, coordination of the hiring procedures for the ESR/ERs, assignment of tasks to the partners, monitoring of the progress of the work in the various work packages, reporting to the EU, and regular audits

8.1 Task 7-1: Recruitment of ESRs.

The 12 ESR positions were widely advertized using Euroaxess, and other job-sites (e.g. Earthworks) as well as through the websites of the partners, and the project website. The table below list the number of views for the various positions from the Euroaxess platform. In total over 800 candidates applied for the 12 positions. The table and figures below give some indications of the number of applications. Detailed information is available on request.

ESR	Euraxess: Number of times read
01	240
02	244
03	191
04	236
05	164
06	176
07	164
08	140
09	213
10	69
11	83
12	82



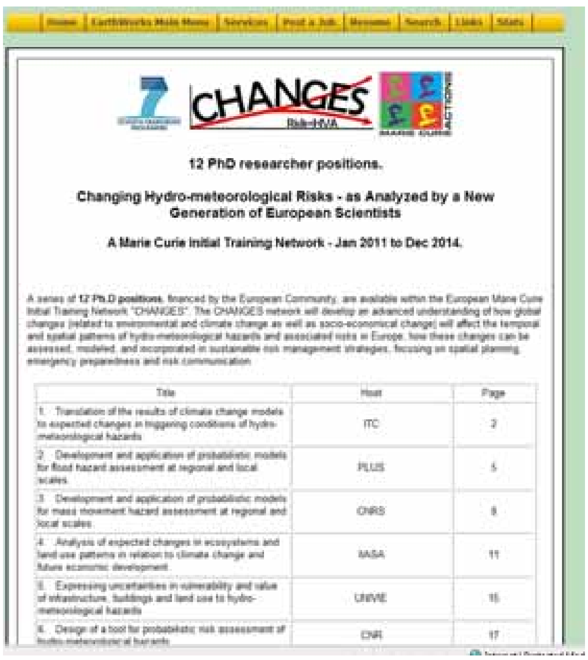
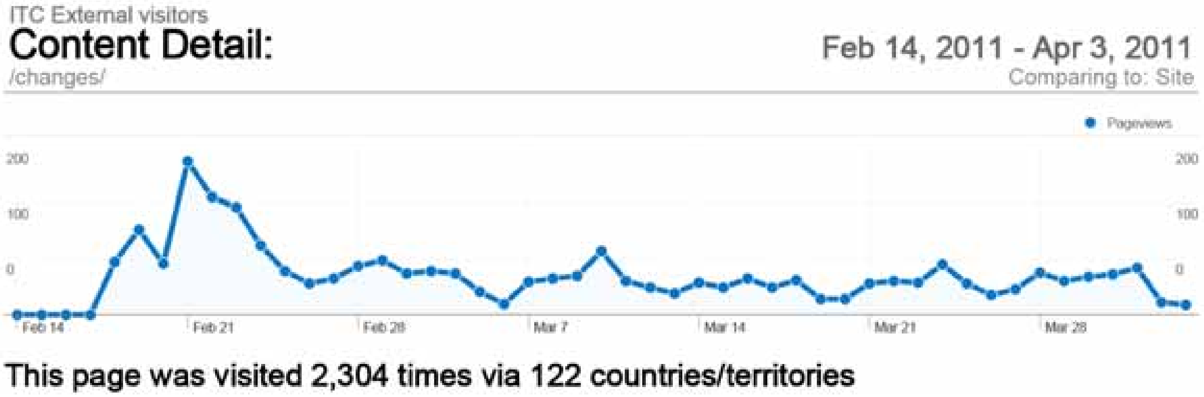


Figure: examples of advertising the job positions on different websites (EurAxess, EGU newsletter, Earthworks).



For the second group of 5 ESRs we advertised the job announcements in early 2013. We received 54 applications of which we selected 5 ESRs.

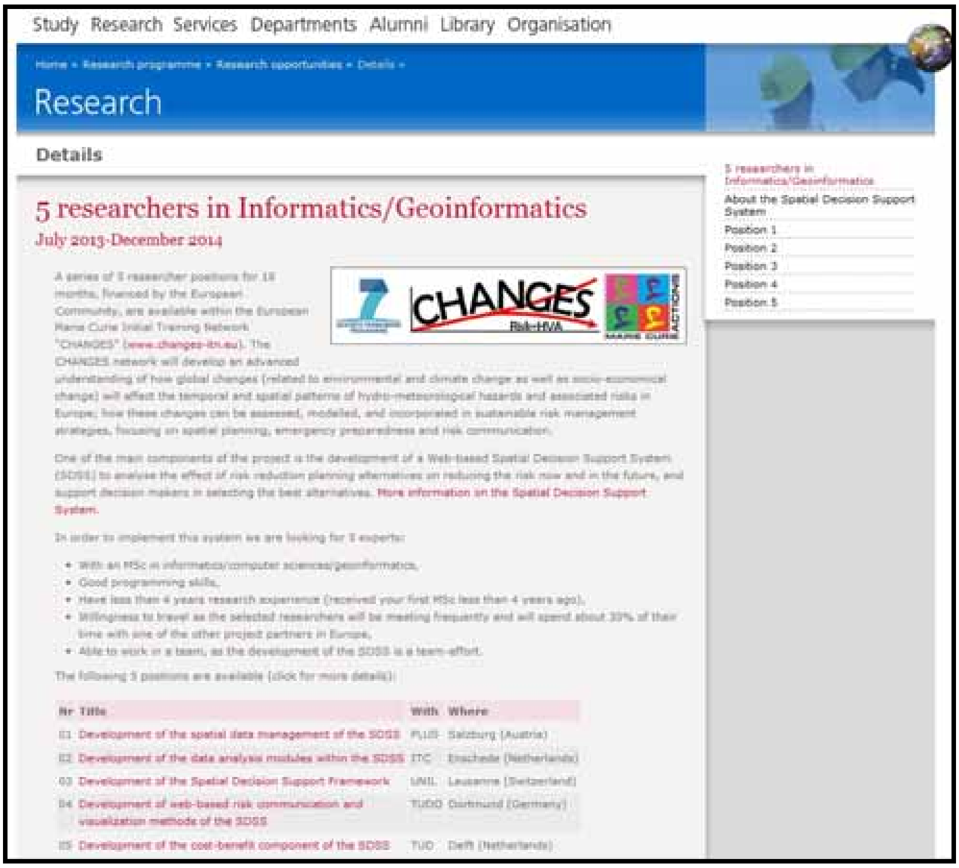
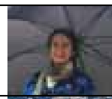
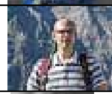
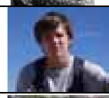
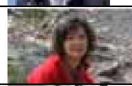
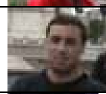
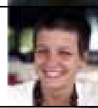
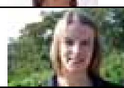
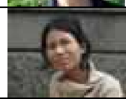
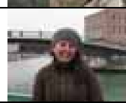
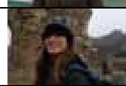
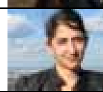
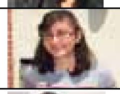
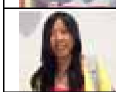
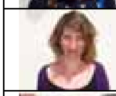


Figure: Announcement of the second group of ESRs in 2013 through the ITC webpage. Also advertising was done through EurAxess and other sites.

Position	Host	Name	M/ F	Country of origin	Start date	Secondments	Photo
ESR01	ITC	Thea Turkington	F	New Zealand	1 Dec 2011	CCRM **and** PLUS	
ESR02	Z-GIS	Korbinian Breinl	M	Germany	10 Oct 2011	ITC **and** Geomer**.**	
ESR03	CNRS	Romy Schlögel	F	Belgium	2 Nov 2011	CNR **and** IGRAC	
ESR04	IIASA	Ziga Malek	M	Slovenia	1 Aug 2011	CCRM **,** ITC **and** PC-FVG**.**	
ESR05	UNIVIE	Roxana Liliana Ciurean	F	Romania	1 Jan 2012	UNIL **and** R&D	
ESR06	CNR	Haydar Hussin	M	Netherlands	15 Sep 2011	ITC **and** ERN	
ESR07	IGRAC	Veronica Zumpano	F	Italy	15 Oct. 2011	UNVIE **and** Geomer	
ESR08	IRM	Kathrin Prenger-Berninghoff	F	Germany	1 Sep 2011	TUDO **and** R&D	
ESR09	UNIL	Zar Chi Aye	F	Myanmar	1 Sept 2011	ERN **and** AS	
ESR10	CNR	Vivian Juliette Cortes Arevalo	F	Colombia	1 Oct 2011	TUD **and** AS	
ESR11	TUDO	Teresa Sprague	F	USA	1 Oct 2011	IRM **and** IIASA	
ESR12	TUD	Marie Charrière	F	Swiss	1 Oct 2011	CNRS **and** PC-FVG	
ESR13	PLUS	Vera Andrejchenko	F	Macedonia	1 July 2013	**ITC, UNIL, TUDO, Geomer, TUD, PLUS**	
ESR14	ITC	Kaixi Zhang	F	China	1 July 2013		
ESR15	UNIL	Roya Olyazadeh	F	Iran	1 July 2013		
ESR16	TUDO	Irina Cristal	F	Moldova	1 July 2013		
ESR17	TUD	Julian Berlin	M	Argentina	1 July 2013		

8.2 Task 7-2: Career Development Plans.

The Career Development Plans have been uploaded in SESAM, and are also available on the CHANGES website: **http://www.changes-itn.eu/Meetings/ESR_Only/tabid/106/Default.aspx** (Note: only accessible for those that have rights to access the ESR-Only part of the website).

8.3 Task 7-3: Steering committee meetings.

In the beginning of the project a Steering committee was established, as well as an advisory committee, external advisor. Regular meetings of the Steering committee.
The management of the network was carried out by a steering committee, consisting of the network coordinator, deputy-coordinator, WP leaders, a representative from the private partners (Geomer), a representative of the ESRs (ESR11, Teresa Sprague) and an external advisor. The steering committee has had 8 meetings in total, and the minutes are available on the web-site to all project partners. In several of the meeting also the members of the external advisory committee (Prof. D. Petley and Dr. S. Lacasse) were present and provided advice.

8.4 Task 7-4: Kick-off meeting.

The proceedings of the kick-off meeting are available on the project website.

8.5 Task 7-5: mid-term meeting.

The mid-term report is available on the project website.

8.6 Task 7-7: Final report.

This final report will also be made available on the project website.

8.7 Task 7-8: Audit report.

Audit reports were made for partners ITC-UT and CNR. .

9. Annexes

9.1 Time, duration, place and objective of each secondment and short visits of ESR/ER to another partner of the network and outside the network

ESR	From	To	Where	Objectives
ESR01 Thea Turkington	27/02/2012	02/03/2012	Salzburg, Vienna Austria	Solidify collaboration for secondment (PLUS), met with researchers at ZAMG for potential collaboration
	16/04/2012	18/04/2012	Barcelonnette	Field visit, Stakeholder meeting
	28/06/2012	07/07/2012	Salzburg, Austria	Development of researh proposal
	01/10/2012	16/11/2012	Salzburg, Austia (PLUS)	Collaboration with ESR02 (PLUS)
	01/07/2013	30/07/2013	Cornwall, UK (CCRM)	Collaboration with other researchers at the institute
	02/03/2014	07/03/2014	Salzburg, Austria (PLUS)	Collaboration with ESR02
ESR02 Korbinian Breinl	12 Dec 2011	15 Dec	CNRS	Discussion of PhD topic and overlaps/collaboration with ESR03
	2 Mar 2012	12 Mar	Bristol University, JBA Trust, UK	Discussion of supervision and topic
	13 Apr 2012	19 Apr	Barcelonnette	Stakeholder Meeting with CNRS
	9 Jul 2012	10 Sep	Geomer	Development of weather generator, review of hydrological/hydraulic models
	1 Feb 2012	27 Apr	ITC	Setting up hydraulic and hydrological model, further development of statistical models, collaboration with ESR01 on including climate component in hydrology
ESR03 Romy Schlögel	04/13 07/13	05/13 08/13	CNR	Statistical multivariate models Field validation of InSAR analysis and preparation of data for hazard assessment
	24/02/14 01/07/14 08/12/14	09/03/14 18/07/14 16/12/14	CNR-IRPI, Perugia	Preparation of data for hazard assessment Slope-unit delineation, Statistical multivariate models
ESR04 Ziga Malek	16.1.2012	27.1.2012	ITC Enschede	Discussing the land use modelling research approach
	18.6.2012	29.6.2012	ITC Enschede	Hyper-temporal satellite image classification
	04.07.2012	27.7.2012	IGAR, Buzau, Romania	Fieldwork, Institute of Geography. Discussion with Romanian researchers on land use changes in Romania
	15.02.2013	03.05. 2013	ITC, Enschede	Visit to ITC
	01.06.2013	19.06.2013	ITC, Enschede	Scenario concept and development
	20.01.2014	24.01.2014	ITC, Enschede	Collaboration on a course at the Department of Natural Resources, presentation and working on a paper
	04./05.2014 (2 weeks)		ITC, Enschede	Will continue to present the research
	5-6 months 2014		UNIVIE	Supervision by Thomas Glade
ESR05 Roxana Liliana Ciurean	4/07/2012	5/08/2012	IGAR, Buzău, Romania	Field work, data collection, stakeholders meeting; joint work with ESR04, ESR07
	05/11/2012	17/11/2012	UNIL, Lausanne, CH	Development of elements at risk database; preliminary work for development of vulnerability curves
	02/03/2013	29/03/2013	R&D, Pau, France	Development of methodological framework; Joint work with ESR08
	13/05/2013	31/05/2013	CNR IRPI Padova, Italy	Field work, data collection, stakeholders meeting; joint work with ESR 06 and ESR

				10
	01/07/2013	29/07/2013	UNIL, Lausanne, CH	Work on state-of-the art paper and local case study vulnerability assessment (Italy)
	16/03/2014	30/03/2014	ITC, Enschede, NL	Supervision and discussion on probabilistic methods for vulnerability assessment
	1/10/2014	31/10/2014	ITC, Enschede, NL	Finalization of regional vulnerability assessment for the Italian case study
ESR06 Haydar Hussin	12/12/2011	14/12/2011	Fella River valley study area and CNR-IRPI. Padua, Italy	First visit to study site and discussions with the Civil Protection Agency of the FVG region
	20/01/2012	26/01/2012	ITC, Enschede, NL	Discussions on research topic, methodology and study area
	28/02/2012	01/03/2012	CNR-IDPA and University of Milan Bicocca, Milan, Italy	Proposal and research discussions
	03/05/2012	19/05/2012	ITC, Enschede, Netherlands	Ph.D. proposal discussions and preliminary presentation with the thesis promoter and supervisor
	12/08/2012	26/09/2012	ITC, Enschede, Netherlands	Supervision and discussion on statistical approaches for probabilistic risk assessment
	30/11/2012	07/12/2012	CNR-IDPA, Milan, Italy	Landslide susceptibility mapping
	26/03/2013	27/03/2013	CNR-IRPI, Padua, Italy	Data collection and analysis for the Fella River study area
	15/05/2013	19/05/2013	Fella River valley study area and CNR-IRPI. Padua, Italy	Meeting with civil protection of Friuli-Venezia Giulia (FVG) region and the Geological service. Participation in fieldwork/survey
	10/07/2013	30/09/2013	ITC, Enschede, Netherlands	Susceptibility and hazard modeling
	10/11/2013	15/11/2013	Fella River valley study area and CNR-IRPI. Padua, Italy	Fieldwork Fella River study area
	30/05/2014	23/06/2014	ITC, Enschede, Netherlands	Preparation for Elements at risk mapping and vulnerability assessment
ESR07 Veronica Zumpano	22/04/2012	07/06/2012	Vienna, Austria Univie	Developing the research proposal. Designing of the geo-DB for the El.at Risk for Buzau County
	10/06/2012	02/07/2012	Heidelberg,Germany Geomer	Designing of the geo-DB for the El.at Risk for Buzau County
	19/11/2012	25/11/2012	Vienna, Austria Univie	Supervising on the ongoing work
	07/01/2013	28/02/2013	Vienna, Austria Univie	Starting to develop a method for risk scenarios
	01/03/2013	30/04/2013	Heidelberg,Germany Geomer	Starting to develop a method for risk scenarios
	01/10/2013	31/10/2013	Vienna, Austria Univie	Modeling uncertainty in risk scenarios
	01/11/2013	30/11/2013	Heidelberg,Germany Geomer	Modeling uncertainty in risk scenarios
	01/06/2013	30/06/2013	Vienna, Austria Univie	Study completion
	01/07/2013	31/07/2013	Heidelberg,Germany Geomer	Study completion
ESR08 Kathrin Prenger-Berninghoff	29.02.2012	29.02.2012	Delft, Netherlands	WP5 Discussion (Marie (ESR-12), Tess (ESR-11), Kathrin (ESR-08), Stefan Greiving (TUDO), Thom Bogaard (TUD), Erik Mostert (TUD), Sandra Junier (TUD))
	31.03.2012	04.04.2012	Friuli-Venezia-Giulia region, Italy	Stakeholder meetings and fieldsite visits
	16.04.2012	20.04.2012	Barcelonnette, France	Stakeholder meetings and fieldsite visits
	12.06.2012	14.06.2012	Krakow and Wieprzówka catchment, Poland	Stakeholder meetings and fieldsite visits
	17.09.2012	19.09.2012	Buzău County, Romania	Stakeholder meetings and fieldsite visits
	14.01.2013	29.03.2013	Urbater/R&D, Pau,	1st secondment: Development of interview

			France	guide and preparation of primary field work
	04.03.2013	08.03.2013	Krakow and Wieprzówka catchment, Poland	Supervising Bachelor group student project at TUDO for 'Good' Governance and the Floods Directive Implementation in Poland
	14.04.2013	27.04.2013	FVG Region, Italy	Fieldwork Italian case study (interviews)
	12.05.2013	25.05.2013	Buzău County, Romania	Fieldwork Romanian case study (interviews)
	23.06.2013	13.07.2013	Barcelonnette, France	Fieldwork French case study (interviews)
	21.08.2013	06.09.2013	Krakow and Wieprzówka catchment, Poland	Fieldwork Polish case study (interviews)
	03.07.2014	07.03.2014	FVG Region, Italy	Supervising Bachelor group student project at TUDO for "Planning for disaster? Planning and disaster risk management in the urban space of the Italian Alps."
	01.04.2014	31.08.2014	TUDO, Dortmund	2nd secondment: Development of indicators and feedback forms for interview partners; Preparation of dissemination material
	30.06.2014	04.07.2014	Krakow and Wieprzówka catchment, Poland	Dissemination of results of Polish case study
	18.11.2014	19.11.2014	Padova, Italy	CHANGES final conference
	20.11.2014	21.11.2014	FVG, Italy	Dissemination of results of Italian case study
ESR09 Zar Chi Aye	11.12.2011	12.12.2011	ERN, Barcelona, Spain	Initial visit for secondment and topic discussions in general
	09.02.2012	09.02.2012	AS, Delft, The Netherlands	Initial visit for secondment and topic discussions in general
	31.03.2012	04.04.2012	Friuli-Venezia-Giulia region, Italy	Initial field visits and stakeholder meetings
	12.06.2012	14.06.2012	Wieprzówka catchment, Poland	Initial field visits and stakeholder meetings
	04.07.2012	07.07.2012	Buzău County, Romania	Initial field visits and stakeholder meetings
	11.03.2013	22.03.2013	ITC, Enschede	Working group meeting: the development of SDSS
	29.05.2013	29.05.2013	Geomer, Heidelberg	Working group meeting: development of SDSS
	30.08.2013	30.08.2013	AS, Delft, The Netherlands	Presention of the planned work and In-depth discussion for follow-ups
	23.10.2013	25.10.2013	Geomer, Heidelberg	Technical workshop: development of SDSS
	27.01.2014	28.02.2014	ITC, Enschede	Secondment
	19.05.2014	21.05.2014	ITC, Enschede	Working group meeting: development of SDSS
	02.07.2014	03.07.2014	IRM and Wieprz, Poland	Dissesmination of results of Polish case study
	22.09.2014	23.09.2014	Friuli-Venezia-Giulia region, Italy	Workshop and dissemination of Italian case study
	11.10.2014	13.10.2014	Buzau County, Romania	Dissesmination of results of Romania case study
	20.11.2014	20.11.2014	Friuli-Venezia-Giulia region, Italy	Dissesmination of results of Italian case study
ESR10 Vivian Juliette Cortes Arevalo	06.02.2012	10.02.2012	TUD, Delft	Introduction and discussion on: Alert Solution's working environment, ESR 09-10's research plan discussion
	09.02.2012	09.02.2012	Alert Solutions	Secondment planning
	19.062012	25.06.2012	UNIL, Lausanne, CH	Data collection activity/ web tools for mapping, Exploring technologies and tools.
	05.07.2012	07.07.2012	IGRAC	Stakheholder meeting
	29.10.2012	29.10.2012	PC-FVG Italy	Discussion and planning secondment

	05.12.2012	11.12.2012	UNIL, Lausanne, CH	Data collection activity/ web tools for mapping, exploring technologies and tools.
	15.03.2013	21.03.2013	TUD, Delft	Data collection activity, first level inspection of hydraulic structures with volunteers
	27.03.2013	02.05.2013	TUD, Delft	Data collection activity, first level inspection of hydraulic structures with volunteers
	14.01.2014	17.01.2014	TUD, Delft	1st Research article, plan of work 2014
	23.02.2014	28.02.2014	ITC, Enschede	Sharing and solving issues with the conding of ExtJs plugins for Opengeo.
	03.03.2014	06.04.2014	TUD, Delft	Dissemination of the methodology for setting priorities on the inspection of structures. Design of the methodology for evaluating the usability of the inspection form in a mobile application
	10.06.2014	1 day	Friuli-Venezia-Giulia region, Italy	Plan the workshop with technicians in September/2014.
	09.08.2014	14.08.2014	Secondment TUD, Delft	Secondment TUD, Delft
	25.07.2014	1day	CNR IDPA, Milano	Progress Meeting and planning of second workshop
	11.09.2014 18.09.2014	1 day 1 day	Friuli-Venezia-Giulia region, Italy Forestry Service, Trento, Italy	Visit to Trento and Palmanova to invite technicians for the workshop in Malborghetho.
	22.09.2014	23.09.2014	Friuli-Venezia-Giulia region, Italy	II workshop: Decision Support methodology to evaluate first level inspections
	20.11.2014	24.11.2014	Friuli-Venezia-Giulia region, Italy	Dissemination meeting in Malborghetto, Trento and Bolzano (Italy)
	01.10.2014	Today	TUD, Delft	Writting publications and PhD thesis
ESR11 Teresa Sprague	29.02.2012	29.02.2012	Delft, Netherlands	WP5 Discussion (Marie (ESR-12), Tess (ESR-11), Kathrin (ESR-08), Stefan Greiving (TUDO), Thom Bogaard (TUD), Erik Mostert (TUD), Sandra Junier (TUD))
	31.03.2012	04.04.2012	Friuli-Venezia-Giulia region, Italy	Stakeholder meetings and fieldsite visits following observational protocol
	16.04.2012	20.04.2012	Barcelonette, France	Stakeholder meetings and fieldsite visits following observational protocol
	11.07.2012	15.07.2012	Wieprzówka catchment, Poland	Stakeholder meetings and fieldsite visits following observational protocol
	17.09.2012	19.09.2012	Buzău County, Romania	Stakeholder meetings and fieldsite visits following observational protocol
	01.11.2012	31.01.2012	IIASA, Austria	1st Secondment
	04.03.2013	08.03.2013	Krakow, Poland	Supervising Bachelor group student project at TUDO for ‘Good’ Governance and the Floods Directive Implementation in Poland
	07.2013	09.2013	Krakow, Poland	2nd Secondment, primary fieldwork Poland (exact date TBD)
	02.2013	05.2013	Barcelonette, France	Primary fieldwork France (exact date TBD)
	02.2013	05.2013	Friuli-Venezia-Giulia region, Italy	Primary fieldwork Italy (exact date TBD)
	07.2013	09.2013	Buzău County, Romania	Primary fieldwork Romania (exact date TBD)
	01.07.2014	05.07.2014	Krakow, Poland	Dissemination for Poland case study site with IRM and Municipality of Wieprz
	11.10.2014	14.10.2014	Buzău, Romania	Dissemination for Romania case study site with IGRAC at Buzău Prefecture, set up support for ESR-12 Exhibition

	17.11.2014	20.11.2014	Perugia, Italy	CHANGES final conference, Dissemination for Italian case study site
	06.2015	06.2015	Barcelonnette, France	(Planned) Dissemination of French case study site
ESR12 Marie Charrière	12.09.11	15.09.12	EOST-Strasbourg	Field work
	16.04.12	19.04.12	EOST-Strasbourg	Field work
	30.06.12	07.07.12	EOST-Srasbourg	Field work
	02.10.12	12.10.12	EOST-Strasbourg	Field work
	23.06. 2013	12.07.2013	EOST-Strasbourg	Field work
	23.09.2013	29.09.2013	EOST-Strasbourg	Field work
	25.11.2013	20.02. 2014	EOST-Strasbourg	Field work
	27.06.2014	04.07.2014	EOST-Strasbourg	Field work
	05.07.2014	02.08.2014	TUDO, Dortmund	Data Analysis
ESR13 Vera Andrejchenko	24.06.2013	26.06.2013	Barcelonette, France	Development of the SDSS
	03.09.2013	06.09.2013	ITC, Enschede	Development of the SDSS
	16.09.2013	20.09.2013	Perugia, Italy	Development of the SDSS
	22.10.2013	25.10.2013	Geomer, Heidelberg	Development of the SDSS
	02.12.2013	06.12.203	Geomer, Heidelberg	Development of the SDSS
	17.02.2014	21.02.2014	ITC, Enschede	Development of the SDSS
			PLUS, Salzburg	Development of the SDSS
	07.04.2014	11.04.2014	Les Diableretes, Switzerland ????	Development of the SDSS
	27.04.2014	02.05.2014	EGU, Vienna	Development of the SDSS
	19.05.2014	30.05.2014	ITC, Enschede	Development of the SDSS
	07.07.2014	11.07.2014	TU Delft, Delft	Development of the SDSS
	18.08.2014	22.08.2014	UNIL, Lausanne	Development of the SDSS
	27.10.2014	31.10.2014	TUDO, Dortmund	Development of the SDSS
	17.11.2014	20.11.2014	CNR, Padova	Development of the SDSS
	08.12.2014	12.12.2014	ITC, Enschede	Development of the SDSS
ESR14 Kaixi Zhang	24.06.2013	26.06.2013	Barcelonette,France	Meeting
	03.09.2013	06.09.2013	ITC, Enschede	Meeting
	16.09.2013	20.09.2013	Perugia, Italy	Meeting
	22.10.2013	25.10.2013	Geomer, Heidelberg	Meeting
	02.12.2013	06.12.2013	Geomer, Heidelberg	Meeting
	17.02.2014	21.02.2014	ITC, Enschede	Meeting
	24.02.2014	29.02.2014	ZGIS, Salzburg	Meeting
	07.04.2014	12.04.2014	Les Diablerets, Switzerland	Meeting
	19.05.2014	23.05.2014	ITC, Enschede	Meeting
	07.07.2014	11.07.2014	TU Delft	Meeting
	18.08.2014	22.08.2014	Laussane	Meeting
	27.10.2014	31.10.2014	Dortmund	Meeting
	08.12.2014	12.12.2014	ITC, Enschede	Meeting
ESR15 Roya Olyazada	24.06.2013	29.06.2013	Barcelonetter,France	Meeting
	03.09.2013	06.09.2013	ITC, Enschede	Meeting
	16.09.2013	20.09.2013	Perugia, Italy	Meeting
	22.10.2013	25.10.2013	Geomer,Heidelberg	Meeting
	02.12.2013	06.12.2013	Geomer,Heidelberg	Meeting
	17.02.2014	21.02.2014	ITC, Enschede	Meeting
	24.02.2014	29.02.2014	ZGIS,Salzburg	Meeting
	07.4.2014	12.04.2014	Les Diablerets,Switzerland	Meeting
	19.05.2014	23.05.2014	ITC, Enschede	Meeting
	02.07.2014	03.07.2014	IRM and Wieprz, Poland	Stakeholders Meeting
	18.08.2014	22.08.2014	UNIL,Lausanne	Meeting
	27.10.2014	31.10.2014	Dortmund	Meeting
	08.12.2014	12.12.2014	ITC, Enschede	Meeting
ESR 16 Irina Cristal	24.06.2013	26.06.2013	Barcelonette,France	CHANGES Meeting
	03.09.2013	06.09.2013	ITC, Enschede	SDSS Meeting
	16.09.2013	20.09.2013	Perugia, Italy	CHANGES Meeting
	22.10.2013	25.10.2013	Geomer, Heidelberg	SDSS Meeting
	02.12.2013	06.12.2013	Geomer, Heidelberg	SDSS Meeting

	17.02.2014	21.02.2014	ITC, Enschede	Coding Week
	24.02.2014	29.02.2014	ZGIS, Salzburg	Coding Week
	07.04.2014	12.04.2014	Les Diablerets, Switzerland	CHANGES Meeting
	27.04.2014	02.05.2014	Vienna, Austria	EGU Conference, SDSS meeting
	12.05.2014	13.05.2014	Alpago, Italy	Observation protocol- Users evaluation
	19.05.2014	23.05.2014	ITC, Enschede	Coding Week
	06.2014	06.2014	Krakow, Poland	Dissemination and Usability evaluation
	07.07.2014	11.07.2014	TU Delft	Coding Week
	18.08.2014	22.08.2014	Laussane	Coding Week
	13.10.2014	18.10.2014	Buzau, Romania	Dissemination and Usability evaluation
	27.10.2014	31.10.2014	Dortmund	Coding Week
	05.11.2014	06.11.2014	ITC, Enschede	SDSS Meeting
	07.11.2014	08.11.2014	Munster, Germany	GeoMundus Conference and Usability evaluation
	18.11.2014	19.11.2014	Padua, Italy	CHANGES conference and dissemination of the results
	08.12.2014	12.12.2014	ITC, Enschede	Final SDSS Meeting
ESR 17 – Julian R Berlin	24.06.2013	29.06.2013	Barcelonette,France	Meeting
	03.09.2013	06.09.2013	ITC, Enschede	Meeting
	16.09.2013	20.09.2013	Perugia, Italy	Meeting
	22.10.2013	25.10.2013	Geomer, Heidelberg	Meeting
	02.12.2013	06.12.2013	Geomer, Heidelberg	Meeting
	24.02.2014	29.02.2014	ZGIS, Salzburg	Meeting
	07.04.2014	12.04.2014	Les Diablerets, Switzerland	Meeting
	19.05.2014	23.05.2014	ITC, Enschede	Meeting
	07.07.2014	11.07.2014	TU Delft	Meeting
	18.08.2014	22.08.2014	Laussane	Meeting
	27.10.2014	31.10.2014	Dortmund	Meeting
	08.12.2014	12.12.2014	ITC, Enschede	Meeting

9.2 Number, name and level of involvement of staff member in the supervision of ESR/ER

ESR	Name	Supervisors	Contributing partners to the research	PhD defence
ESR01	Thea Turkington	Dr. Victor Jetten (ITC) Dr. Cees van Westen (ITC) Dr. Janneke Ettema (ITC)	Dr. Stefan Kienberger (PLUS), Dr. Steven Harrison (CCRM), Dr. Peter Zeil (PLUS)	Expected defence of PhD thesis: December 2015
ESR02	Korbinian Breinl	Prof. Josef Strobl (PLUS) Dr. Stefan Kienberger (PLUS) Dr. Rob Lamb (JBA Trust)	Dr. Dinand Alkema (ITC), Dr. Stefan Jäger (Geomer), Prof. Paul Bates (Bristol University), Dr. Markus Stowasser (Allianz SE Reinsurance) Prof. Ulrich Strasser (University Innsbruck)	Defended his PhD thesis in February 2015
ESR03	Romy Schlögel	Dr. Jean-Philippe Malet (CNRS) Dr. Cécile Doubre (CNRS) Dr. Fréderic Masson (CNRS)	Dr. Paola Reichenbach (CNR), Dr. Mihai Micu (IGRAC)	12/02/2015 - Quantitative landslide hazard assessment with remote sensing observations and statistical modelling
ESR04	Ziga Malek	Prof. Dr. Thomas Glade (UniVie) Dr. Anthony Patt (IIASA, ETH Zurich)	Prof. thomas Glade (UNIVIE), Dr. Luc Boerboom (ITC), Prof. Tony Patt (IIASA, now ETH), Dr. Dagmar Schroter (IIASA, now ETH)	Defended his PhD thesis on 19 January 2015

		Dr. Dagmar Schröter (IIASA, ETH Zurich)		
ESR05	Roxana Liliana Ciurean	Prof. Thomas Glade (UNIVIE) Prof. Michel Jaboyedoff (UNIL) Dr. Eric Leroi (R&D)	Cees van Westen (ITC), Dr. Simone Sterlacchini (CNR-IDPA), Dr. Simone Frigerio (CNR-IRPI)	August 2015. Title: 'Quantifying uncertainties in vulnerability assessment of infrastructure and buildings to hydro-meteorological hazards'
ESR06	Haydar Hussin	Prof. Victor Jetten (Promoter, ITC) Dr. Paola Reichenbach (Co-Promoter and daily supervisor, CNR-IRPI) Dr. Cees van Westen (Co-promoter and supervisor, ITC)	Dr. Simone Sterlacchini (CNR-IDPA) Dr. Simone Frigerio (CNR-IRPI) Dr. Gianluca Mercato (CNR-IRPI) Dr. David Rossiter (ITC) Dr. Jean-Philippe Malet (CNRS) Dr. Alexandre Remaitre (CNRS)	Expected defence of PhD thesis: December 2015
ESR07	Veronica Zumpano	Prof. Dan Balteanu (IGRAC)	Prof. Thomas Glade (UNIVIE), Dr. Stefan Jager (GEOMER)	31 March 2015.
ESR08	Kathrin Prenger-Berninghoff	Mr. Wiktor Glowacki (IRM) Prof. Dr.-Ing Stefan Greiving		Expect6ed PhD defence in December 2015
ESR09	Zar Chi Aye	Prof. Michel Jaboyedoff, Dr. Marc-Henri Derron		Development of an integrated web-based decision support platform for use of risk information in risk reduction; end of August (approximation)
ESR10	Vivian Juliette Cortes Arevalo	D. Alessandro Pasuto (CNR-IRPI) Dr. Simone Sterlacchini (CNR-IDPA) Dr. Thom Bogaard (TUDelft) Prof. Nick van de Giesen (TUDelft)	Dr. Simone Frigerio (CNR-IRPI) Dr. Luca Schenato (CNR-IRPI) Claudio Garlatti (CP-FVG) Giulia Bossi (CNR-IRPI) Sandra Junier (TUDelft) Chiara Bianchizza (ISIG)	Title « Practical use of volunteers' information to support risk management strategies of hydro-meteorological hazards » September 2015
ESR11	Teresa Sprague	Prof. Dr.-Ing Stefan Greiving Prof. Dr.-Ing Sabine Baumgart (PhD advisor) PD Dr.-Ing. Jörn Birkmann (PhD external advisor)	Prof. Dr.-Ing Stefan Greiving (TUDO); Dr. Thom Bogaard, Dr. Erik Mostert, Mrs. Sandra Junier (TUD); Dr. Anna Scolobig, Dr. Anthony Patt, Dr. Dagmar Schroeter (formerly of IIASA, now ETH Zurich); Dr. Mihai Micu (IGRAC); Dr. Simone Frigerio, Dr. Alessandro Pasuto (CNR); Dr. Jean-Philippe Malet (CNRS); Mr. Wiktor Glowacki (IRM)	Expected date: 11.2015 Title: *"Good" Risk Governance Strategies for Hydro-Meteorological Risks: a European comparison of in-practice strategies to improve disaster risk reduction policy*
ESR12	Marie Charrière	Dr. Thom Bogaard (TUDelft) Dr. Erik Mostert (TUDelft) Prof. Nick van de Giesen (TUDelft)	Sandra Junier (TUDelft), Sisi Zlatanova (TUDelft), Dr. Jean-Philippe Malet (CNRS-Strasbourg), Dr. Simone Frigerio and Dr. Alessandro Pasuto (IRPI), Prof. Dr. Stefan Grieving (TUDO)	December 2015
ESR13	Vera Andrejchenko	Wim Bakker (ITC)	Peter Zeil, Stefan Kienberger	No PhD planned.

		Cees van Westen (ITC)		Research period was only 18 months
ESR14	Kaixi Zhang	Wim Bakker (ITC), Cees van Westen (ITC)	Luc Boerboom (ITC)	No PhD planned. Research period was only 18 months
ESR15	Roya Olyazadeh	Wim Bakker (ITC), Cees van Westen (ITC)	Michel Jaboyedoff	No PhD planned. Research period was only 18 months
ESR16	Irina Cristal	Wim Bakker (ITC), Cees van Westen (ITC)	Stefan Greiving	No PhD planned. Research period was only 18 months
ESR17	Julian Berlin	Wim Bakker (ITC), Cees van Westen (ITC)	Thom Boogaard, Emile Dopheide	No PhD planned. Research period was only 18 months

9.3 Time, duration, place and objective of short visits of students (MsC and PhDs) to another partner of the network and outside the network

Name	Host	MSC/PhD	Date/Duration	Place of visit	Purpose
Aroshaliny Godfrey (India)	ITC	MSC	September 2012, 3 weeks	Buzau county, Romania	Fieldwork Nehoiu study area on elements at risk mapping
Rodrigo Lopez Rangel (Mexico)	ITC	MSc	September 2012, 3 weeks	Buzau county, Romania	Fieldwork Nehoiu study area on elements at risk mapping
Azadeh Ramesh (Iran)	UNIVIE	Phd	2011 Several months	ITC	Flood modeling
Catrin Promper (Austria)	UNIVIE	PhD	2012 1 week	ITC	Workshop at ITC
			Sept. 2012, 1 week	Buzau county, Romania	Participation in CHANGES meeting
Michele Santangelo (CNR)	CNR	PhD	2012 1 week	ITC	Followed a 1 week course together with ESRs
Eva-Marie Hater (Germany)	TUDO	MSc	Nov. 2012	TUDO	Participation in CHANGES midterm meeting
Marlena Abel (Germany)	TUDO	MSc	Nov. 2012	TUDO	Participation in CHANGES midterm meeting
Lei Gui (China)	UNIVIE	PhD (visiting)	June 2013, 8 days	Barcelonnette, France	Participation in CHANGES meeting (FORMOSE Summer School)
Mohammadali Hadian-Amri (Iran)	UNIVIE	PhD (visiting)	Sept. 2012, 1 week	Buzau county, Romania	Participation in CHANGES meeting
Bamidele Rotimi Ayoniyi (Nigeria)	UNIVIE	PhD	April 2014, 5 days	Les Diablerets, Switzerland	Participation in CHANGES meeting
Lixia Chen (China)	ITC	PhD	2014 (6 months)	Fella area	Participating in research in Fella
Jian Huang (China)	ITC	PhD	2014 (2 months)	Fella area	Participation in fieldwork in Fella

9.4 List of courses (language, communication, culture), internet tutorial and computed based training lessons

ESR	Place / Period	Type of course
ESR01 Thea Turkington	08-15 Feb, 2012	Dutch language course, University of Twente
	June 28-30, 2012	Environmental Data Quality, University of Twente
	July – August 2012	Variety of MetEd online course, UCAR
ESR02 Korbinian Breinl	ITC (distance learning) / Jan 2012 – Mar 2012	Geostatistics and Open-Source Statistical Computing
ESR03 Romy	Univ. Strasbourg, 04-10/2011	Introduction to InSAR

Schlögel	Univ. Strasbourg, 11/2011 Univ. Strasbourg, 11/2012 Univ. Strasbourg, 11/2012 Univ. Strasbourg, 12/2012	Introduction to IDL programming Image processing with IDL language PcRaster trainign course Organizaiton of Doctoral School Congress
ESR04 Ziga Malek	University of Vienna, January 2012	Mountain Geomorphology and Global Environmental Change
	ITC Enschede, May 2012	Hyper-Temporal Earth Observation Data Analysis for Food Security and Biodiversity Assessment. SENSE – Research School for Socio-Economic and Natural Sciences of the Environ-ment, Summer Academy 2012
	University of Vienna, March-June 2012	Risk Assessment and Disaster Management/Exercises for Risk Assessment and Disaster Management - Lectures on theory and concepts in Disaster Risk Management/Practical applications and exercises for risk assessment and disaster management (ITC Course)
	University of Vienna, October 2012 – January 2013	Theory and Methods of Geographic Information Science – Lectures on theory and concepts of GIScience
	University of Vienna, March – June 2013	Environmental Statistics using R
	ITC Enschede, July 2013	Certificate in Geo-Information Science and Earth Observation: Scenario Development and Decision Support in Spatial planning
ESR05 Roxana Liliana Ciurean	UNIVIE/January 2012 - present	Konversatorium zur Geomorphologie, 'Forschungsseminar' (for Doctoral Studies) - Scientific discussions, seminars
	UNIVIE/summer semester 2012	Risk Assessment and Disaster Management/Exercises for Risk Assessment and Disaster Management – Lectures on theory and concepts in Disaster Risk Management/Practical applications and exercises for risk assessment and disaster management (ITC Course)
	UNIVIE/winter semester 2012	Mountain Geomorphology and Global Environmental Change
	UNIVIE/winter semester 2013	Theory and Methods of Geographic Information Science – Lectures on theory and concepts of GIScience
	SENSE network/8 – 10 October 2012	Dealing with Uncertainty in research for climate adaptation – Lectures on theory, concepts, methods of assessment, communication and visualisation of uncertainty; practical applications and exercises
	UNIVIE/winter semester 2013	Theory of Science for geographers, spatial planners and cartographers
	ÖH/September 2013 - present	German Language courses: levels A1/2 – B1
ESR06 Haydar Hussin	2-6, July, 2012, Salzburg, Austria	Workshop and professional skills course on moderating and presenting scientific proposals
	3-19, May, 2012, ITC, Enschede, Netherlands	Online Statistical course for R-statistics
	3-19, May, 2012, ITC, Enschede, Netherlands	Online Statistical course for Matlab
ESR07 Veronica Zumpano	Risk Assessment and Disaster Management/Exercises for Risk Assessment and Disaster Management – UNIVIE/March – June 2012	Lectures on theory and concepts in Disaster Risk Management/Practical applications and exercises for risk assessment and disaster management (ITC Course)
	British Council, Bucharest (Jan-Feb-March)	English Course
ESR08 Kathrin Prenger-Berninghoff	Krakow,Poland/ongoing	Polish Language
ESR09 Zar Chi Aye	Autumn semester 2011, UNIL, Lausanne	French (Complete Beginners)
	21 Nov – 2 Dec 2011, Chengdu	LARAM Asia course 2011
	9 – 13 Jan 2012, UNIL, Lausanne	English (Module Intensive) – Level C1
	20 Feb – 28 May 2012, EPFL, Lausanne	GIS in decision making course
	23 July – 10 Aug 2012, UNIL, Lausanne	French (Module Intensive) – Level A1/A2

	22 July – 09 Aug 2013, UNIL, Lausanne	French (Module Intensive) – Level A2/B1
	15 – 16 Nov 2013, UJI, Castelló	Android platform development course
ESR10 Vivian Juliette Cortes Arevalo	University of Padova, Nov-Dec 2012	Italian course
	(1 month) Jan 2012, ITC, Enschede, Netherlands	Module 6: Spatial Data Modelling of Geoinformatics Specialization
ESR11 Teresa Sprague	TUDO/10.2011-11.2011	German Language (ASTAS, Intensive)
	TUDO/12.2011-02.2012	German Language (Language Center, Non-Intensive)
	TUDO/Winter Semester	Spatial Data Analysis and Mapping
	TUDO/Winter Semester	Spatial Planning and Decision-Making Theories
	TUDO/Spring Semester	Land Use Planning
ESR12 Marie Charrière	TUDelft/October 2011	Research Design
	TUDelft/Fall semester 2012	Geo-technologies for disaster management
	Delft/2011-2012	Dutch
ESR 13 Vera Andrejchenko	Salzburg 2013	OBIA (Object based Image Analysis) course
ESR15 Roya Olyazadah	Intensive French course, UNIL, Lausanne, Switzerland	French (Beginners) Level A1 July 2013
	Intensive French course, UNIL, Lausanne, Switzerland	French (Beginners) Level A1 August 2013
	15 – 16 Nov 2013, UJI, Castellón	Android platform development course
	Intensive French course, UNIL, Lausanne, Switzerland	French (Beginners) Level A2 Jan 2014
	7-13 September,FOSS4G 2014, Porltand, USA	Workshop on OpenSource Software , FOSS4G 2014 Portland
	7-8 November 2014,IFGI,Germany	Mobile platform development course
ESR17 Julian Berlin	Dutch course at the municipality of Delft	Dutch introductory Language course
	Barcelonnette Changes meeting	GIS Course
	Le Diablarets, Changes meeting	Project management course

9.5 Stakeholder workshops organized by the network

Location	**Date**	**URL**
Buzau, Romania	July 2011	**http://changes-itn.eu.dnnmax.com/StudyAreas/Romania/tabid/82/Default.aspx**
	July 2012	
	September 2012	
	May 2012	
	April 2013	
	13-17 October 2014,	"Alerte" exhibition
Poland. Wieprzówka catchment	June 2012	**http://changes-itn.eu.dnnmax.com/StudyAreas/Poland/tabid/83/Default.aspx**
	August/September 2012	
	June 2014	
Italy. Friuli-Venezia-Giulia region	December 2011	**http://changes-itn.eu.dnnmax.com/StudyAreas/Italy/tabid/81/Default.aspx**
	April 2012	
	October 2012	
	March 2013	
	September 2014	
	November 2014	
Barcelonnette, France	April 2012	**http://changes-itn.eu.dnnmax.com/StudyAreas/FrenchAlps/tabid/80/Default.aspx**
	June/July 2012	
	04 December 2013 – 19 February 2014	"Alerte" exhibition

9.6 Other networking activities

See also website: **http://changes-itn.eu.dnnmax.com/Meetings/tabid/66/Default.aspx**

Location	Date	Objective
ITC, Enschede, Netherlands	January 13-14, 2011	Kick-off meeting
UNIVIE, Vienna	April 6, 2012	Steering committee meeting, and presentation of the project to external advisors
Buzau, Romania	July 18 – 21, 2011	Stakeholder meeting and visit Romanian study site
Fella river, Italy	December 12-13, 2011	Field visit and stakeholder meeting, Fella River, Italy
ITC, Enschede, Netherlands	January 16 – 20, 2012	PS02: Professional skills course: Research ethics TS01b: Training course on Multi-Hazard Risk Assessment CHANGES seminar Meeting of the ESRs and supervision teams to discuss research plans (CHANGES only)
University of Vienna	March – June 2012	Risk Assessment and Disaster Management/Exercises for Risk Assessment and Disaster Management – UNIVIE Lectures on theory and concepts in Disaster Risk Management/Practical applications and exercises for risk assessment and disaster management (ITC Course)
Salzburg, Austria	July 2-6, 2012	Young Researcher Forum on Climate Change and Disaster Risk Management GI-Forum Professional Skills course: Moderating Field visit
Dortmund, Germany	November 27-29 2012	Midterm Meeting
Meeting Enschede	14 and 15 March 2013	To start up the brainstorming work on the development of the web-based spatial decision support system, a meeting was organized in ITC on 14 and 15 March 2013 in ITC. The following person participated in the meeting: Stefan Jaeger (Geomer), Cees van Westen (ITC), Johannes Flacke (ITC), Luc Boerboom (ITC), Javier Morales (ITC), Roxana Ciuerean (ESR UNIVIE), Korbinian Breindl (ESR Salzburg), Ziga Malek (ESR IIASA), Thea Turkington (ESR (ITC), Zar Chi aye (ESR (Lausanne), Michel Jaboyedoff (University of Lausanne), Simone Frigerio (CNR IRPI) and Thom Bogaard (TU Delft). The aim of this workshop was to develop the workflow for the various components of the system, and to learn from other comparable systems.
Meeting Heidelberg	29 May 2013	The meeting was organized by the people from Geomer. Venue was the IWH in Heidelberg. Present at the meeting are: Michel Jaboyedoff (UNIL), Zar Chi Aye (UNIL), Luc Boerboom, (ITC) Cees van Westen (ITC), Christian Lindner (TUDO), Stefan Jäger (Geomer), André Assman (Geomer), Steve Kass (Geoville), Wim Bakker (ITC). It was agreed that the design of the system should follow open standards. UML can be used for the communication. For the toplevel design we make use of Use Case diagrams. During this meeting also the candidates for the 5 positions for the development of the system were discussed.
Barcelonnette in the French Alps	24-29 June 2013	This workshop was organized as an intensive course within the EU FP7 CHANGES project. This was the first meeting in which the 5 Early Stage Researcher attended that were hired within the CHANGES project to work on the development of the SDSS. The intensive course dealt with risk assessment methods, risk reduction measures and Spatial Decision Support Systems by a number of international experts
Enschede, The Netherlands	3-6 September 2013	The first work meeting with the 5 Early Stage Researchers was organized from 3-6 September in ITC, Enschede, The Netherlands. The main objective of this meeting was to go

		through the various components of the planned system, and the teach the new researchers more about the risk assessment method, the definition of alternatives, scenarios etc. The majority of this meeting did not yet deal with development issues, but more with extensive brainstorm session using whiteboards.
Perugia, Italy	16 – 19 September, 2013	From 16 – 19 September a workshop was organized in Perugia, Italy. The aim of this workshop was to present the ongoing development of the system to a larger group of colleagues, which are part of the Marie Curie CHANGES network. Moderated by Dr. Peter Zeil, from the University of Salzburg, the main challenges in the development of the SDSS were Identified: coordination, prioritization, design of data input, background architecture, metadata, dummy dataset, terminology and hosting of the system. Follow-up activities were identified in terms of coordination of the work, definition of terminology, architecture design of the system, metadata description and implementation plan
Heidelberg. Germany	24 and 25 October, 2013	We decided to organized regular working meetings, as the developers are located in different cities. On 24 and 25 October a meeting was organized in Heidelberg. One day earlier, on 23 October the ESRs met in Geomer together with Sebastian, the expert on OpenGeo in Geomer, to discuss the technical aspects of OpenGeo. During the meeting the following aspects were discussed: Overview of the system as we see it now (Cees); Data structure (Vera); Use cases (Julian and Wim); Case study data (Steve); Loss estimation method (Kaixi); Visualization methods (Irina); Technical implementation planning (Wim); Risk assessment method (Cees and Kaixi); Cost-benefit analysis (Julian); Alternative selection (Roya and Zar Chi); Multi-Criteria Evaluation (Roya and Zar Chi); Portable version of the tool (Stefan); Planning of the deliverables (Wim)
Heidelberg	2-4 December 2013	During this working meeting the individual components of the system were presented and discussed. During the meeting in Enschede the technical aspects related to the system architecture and hosting were discussed, and the developers worked on the programming of the first components. Also the draft deliverable 303-2 was prepared and discussed.
Barcelonnette, France	04 December 2013 – 19 February 2014,	“Alerte” exhibition organized by Marie Charriere.
Nehoiu, Romania	13-17 October 2014,	Alerte” exhibition organized by Marie Charriere.

9.7 ESR/ER networking activities

Date	Location	Objective	ESRs participating
20.09.2011	Poland	Icebreaker – get to know one another	ESRs 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12
25.11.2011	Skype	WP4&5 Meeting	Kathrin (ESR-08), Zar Chi (ESR-09), Juliette (ESR-10), Tess (ESR-11), Marie (ESR-12)
23.01.2012 – 27.01.2012	ITC	Alignment of research	ESR 01, ESR 02, ESR 04, ESR 06, ESR 10 (partly)
9-02-2012	Delft, Alert Solutions	Introduction and discussion on the’ research plan discussion	ESR 09 and 10
22.02.2012	Skype	Young Researchers Forum Info and Discussion	All ESRs who could attend & Peter Zeil
28-29 February 2012	CNR-IDPA and University of Milan Bicocca, Milan, Italy	Proposal and research discussions	ESR-06, ESR-10

05.03.2012	Skype	WP4&5 Meeting	Kathrin (ESR-08), Zar Chi (ESR-09), Juliette (ESR-10), Tess (ESR-11), Marie (ESR-12)
20 – 25 March	Buzău, Romania	Field work, stakeholders meeting	ESR05, ESR07
27 March, 2012	Padua, Italy	Discuss overlaps in research/proposals	ESR01, 02, 04, 05, 06, 07, 08, 09, 10, 11, 12
2-3 April 2012	Friuli Venezia Giulia Region, Italy	Stakeholders Meeting	ESR04, ESR05, ESR07, ESR08, ESR09, ESR11, ESR12
24.04.2012	Skype	ESR Meeting	Marie (ESR-12), Kathrin (ESR-08), Tess (ESR-11)
3-19 May 2012	ITC, Enschede, Netherlands	Part of the secondment. Discussions with ESR-01 on climate change and triggers	ESR-06, ESR-01
30.05.2012	Skype	ESR Bilateral Meeting	Kathrin (ESR-08), Tess (ESR-11)
31.05.2012	Skype	ESR Bilateral Meeting (Questionnaires)	Tess (ESR-11), Marie (ESR-12)
01.06.2012	Skype	ESR Bilateral Meeting (Questionnaires, continued)	Tess (ESR-11), Marie (ESR-12)
04.06.2012	Skype	ESR Bilateral Meeting (Questionnaires)	Kathrin (ESR-08), Tess (ESR-11)
06.06.2012	Delft, Netherlands	Discuss and correct content for questionnaire draft	Marie (ESR-12), Tess (ESR-11)
26-06-2012 01-07-2012	Lausanne, Switserland	To explore collaboration for the web-platform for volunteers activity	ESR 09 and 10
02 July, 2012	University of Salzburg, Austria	Discuss PhD progress/problems	ESR01, 02, 04, 05, 06, 07, 09, 10
07.06.2012	Skype	ESR Meeting (Questionnaires)	Marie (ESR-12), Tess (ESR-11), Zar Chi (ESR-09), Kathrin (ESR-08), Juliette (ESR-10)
11 September, 2012	Romania	Discuss progress/problems	ESRs 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12
17-20 September 2012	Buzău, Romania	Field work, stakeholders meeting	ESR04, ESR05, ESR07, ESR08, ESR11, Aroshaliny Godfrey,, Rodrigo Lopez (ITC Enschede, Netherlands)
11.10.2012	Skype	ESR Meeting (Del. 4.1 Discussion)	Kathrin (ESR-08), Juliette (ESR-10), Tess (ESR-11)
15.11.2012	IIASA	Discuss PhD progress	Tess (ESR-11), Anna Scolobig (IIASA)
11.12.2012	IIASA	Discuss PhD progress	Tess (ESR-11), Dagmar Schroeter (IIASA)
06.12.2012	Skype	ESR Meeting (Del. 4.1 Discussion)	Kathrin (ESR-08), Juliette (ESR-10), Tess (ESR-11), Zar Chi (ESR-09), Marie (ESR-12)
12.12.2012	Skype	Discussion publications	Tess (ESR-11), Juliette (ESR-10)
08.01.2013	Skype	Discussion (EGU, AESOP, Interviews prep)	Tess (ESR-11), Kathrin (ESR-08)
15.01.2013	UNIVIE	Presentation and discussion for Roxana (ESR-05)	Tess (ESR-11), Roxana (ESR-05), (all attending presentation)
21.01.2013	(1) IIASA	(1) Discuss PhD	(1) Tess (ESR-11), Anna Scolobig (IIASA)

	(2) Skype	progress (2) Steering Committee Meeting	(2) Steering Committee
22-23.01.2013-	Skype	Discussion (Interviews prep)	Tess (ESR-11), Kathrin (ESR-08)
23.01.2013	UNIVIE	(1) Discuss PhD progress (2) Presentation and discussion for Žiga (ESR-04)	(1) Tess (ESR-11), Thomas Glade (UNIVIE) (2) Tess (ESR-11), Žiga (ESR-04), (all attending presentation)
24.01.2013	IIASA	Discuss PhD progress	Tess (ESR-11), Dagmar Schroeter (IIASA)
06.02.2013	Skype	Discuss collaboration	Tess (ESR-11), Kathrin (ESR-08), Marie (ESR-12)
16.04.2013	IIASA	Discuss PhD progress	Tess (ESR-11), Anna Scolobig (IIASA)
29.04.2013	Skype	Discuss fieldwork prep	Tess (ESR-11), Kathrin (ESR-08), Mihai Micu (IGRAC)
28.05.2013	TUDO	Discuss PhD progress and collaborations	Tess (ESR-11), Kathrin (ESR-08), Marie (ESR-12), Thom Bogaard (TUD), Erik Mostert (TUD), Stefan Greiving (TUDO)
30.05.2013	Skype	Discuss fieldwork prep	Tess (ESR-11), Kathrin (ESR-08), Jean-Philippe Malet (CNRS)
03.06.2013	Skype	ESR Meeting (Del. 4.1 publication discussion)	Kathrin (ESR-08), Juliette (ESR-10), Tess (ESR-11), Zar Chi (ESR-09)
20.06.2013	Skype	WP4&5 questionnaire	Kathrin (ESR-08), Juliette (ESR-10), Tess (ESR-11), Zar Chi (ESR-09), Marie (ESR-12)
06.12.2013	Skype	Bilateral meeting for collaboration	Tess (ESR-11), Marie (ESR-12)
13.03.2014	Skype	Discussion Romanian dissemination prep	Tess (ESR-11), Mihai Micu (IGRAC)
07.04.2014	Les Diablerets, Switzerland	ERS meeting	All ESRs
28.05.2014	Skype	Discussion Romanian dissemination prep	Tess (ESR-11), Zar Chi (ESR-09), Irina (ESR-16)
30.07.2014	Skype	Discussion of next NHESS article contribution from WP4&5 work	Tess (ESR-11), Zar Chi (ESR-09)
01.2013	CNR-IRPI, Padova, Italy	Planning of data collection activity with volunteers	Juliette (ESR-10) and Marie (ESR-12)
03.2013	CNR-IRPI, Padova, Italy	Field work and data collection activity	Juliette (ESR-10) and Roxana (ESR-04)
24.02-03.03.2014	ITC, Enschede, The Netherlands	Exploring Open-Geo tools and coding	Juliette (ESR-10) and Zar-Chi (ESR-09)
20.09-24.04-2014	CNR-IRPI, Padova, Italy	Workshop II at Malborghetto with technicians	Juliette (ESR-10) and Zar-Chi (ESR-09)
26.08.2014	TUDO	Discuss PhD progress and collaborations	Tess (ESR-11), Kathrin (ESR-08), Stefan Greiving (TUDO)
28.08.2014	Skype	Discussion of next NHESS article contribution from WP4&5 work	Tess (ESR-11), Zar Chi (ESR-09)
10.09.2014	Skype	Discussion publication collaboration	Kathrin (ESR-08), Juliette (ESR-10), Tess (ESR-11), Zar Chi (ESR-09)
05+07.11.2014	Skype	Discussion Italian dissemination prep	Juliette (ESR-10), Tess (ESR-11), Simone Frigerio (CNR)

13 – 31 May 2013	Friuli Venezia Giulia Region, Italy	Fieldwork, stakeholders meeting	Juliette (ESR-10), Marie (ESR-12), Roxana (ESR-05)
10 – 14 November 2013	Friuli Venezia Giulia Region, Italy	Fieldwork, stakeholders meeting	Roxana (ESR-05), Haydar (ESR-06)
1 – 31 October 2014	ITC, Enschede	Discuss overlaps in research and collaborations	Haydar (ESR-06), Lixia CHEN (ITC), Thea (ESR-01), Roxana (ESR-05)

9.8 Participation to training events organized outside the network

ESR	Place / Period	Type of course
ESR01 Thea Turkington	June 18-21, 2012	Moderation course, University of Salzburg
	June 28 2012	SENSE Summer Acadamy, University of Twente
ESR02 Korbinian Breinl	July 2-6, 2012	Moderating course, University of Salzburg
	16 Jul – 20 Jul, 2012, Bristol, UK	CABOT summerschool on natural hazards and risk (Bristol University)
	February 2, 2014	Leadership skills for young professionals (Uni Salzburg)
	October 15, 2014	How to write grant proposals (Uni Salzburg)
ESR03 Romy Schlögel	July-August, 2013, Online course	The Data Scientist's Toolbox, Coursera Verified Certificate (https://www.coursera.org/signature/certificate/9VLEJ7C7EQ)
ESR04 Ziga Malek	July 2-6, 2012	Moderating course, University of Salzburg
	ITC Enschede, June 18-21 2012	Use of hyper-temporal remote sensing data in agricultural and biodiversity studies
	13 - 16 March, 10 - 13 April, 04 - 07 June 2012	Risk Assessment and Disaster Management, UNIVIE, Vienna, Austria
ESR05 Roxana Liliana Ciurean	July 2-6, 2012	Moderating course, University of Salzburg
	13 - 16 March, 10 - 13 April, 04 - 07 June 2012	Risk Assessment and Disaster Management, UNIVIE, Vienna, Austria
	UNIVIE/November 2013, January 2014	Personal development courses (Presentation Techniques, Time Management, Brain Read)
ESR06 Haydar Hussin	July 2-6, 2012	Moderating course, University of Salzburg
	June 13, 2013	GIT 2013– Oral Presentation, Chiavenna (Italy)
	31 August -13 September, 2014	International Summer School on Landslide Risk Assessment and Mitigation (LARAM 2014)
ESR07 Veronica Zumpano	July 2-6, 2012	Moderating course, University of Salzburg
	13 - 16 March, 10 - 13 April, 04 - 07 June 2012	Risk Assessment and Disaster Management, UNIVIE, Vienna, Austria
ESR08 Kathrin Prenger-Berninghoff	Summer/Spring Semester (2011-2012)	MAXQDA Software (Graduate Training Program, TU Dortmund)
ESR09 Zar Chi Aye	21 Nov – 2 Dec 2011, Chengdu	LARAM Asia course 2011, Chengdu University of Technology
	July 2-6, 2012, Salzburg	Moderating course, University of Salzburg
	20 Feb – 28 May 2012, Lausanne	GIS in Decision Making course, EPFL
	01 April 2014, UNIL, Lausane	Workshop on "Preparing to present your thesis to a jury and to the public"
ESR10 Vivian Juliette Cortes Arevalo	July 2-6, 2012	GIResearch Forum - Workshop and professional skills course on presenting scientific proposals
	20-22 November, Rotterdam, The Netherlands	FLOODrisk 2012
	June 13, 2013	GIT 2013– Oral Presentation, Chiavenna (Italy)
	May 15, 2014	Workshop Valuing benefits and costs of flood risk mitigation strategies, StartUp Project. Bolzano (Italy)
	August 17 - 21, 2014	Oral presentation

		HIC 2014 _ 11th International Conference on Hydroinformatics & Informatics and the Environment: Data and Model Integration in a Heterogeneous Hydro World; New York, USA August 17 - 21, 2014
ESR11 Teresa Sprague	July 16-20, 2012	WaterDoss2.0 Summer Academy, Oxford
	Winter Semester (2011-2012)	Literature Research and Time Management (Graduate Training Program, TU Dortmund)
	Winter Semester (2011-2012)	Academic Writing (Graduate Training Program, TU Dortmund)
	Winter Semester (2011-2012)	Citavi Software (Graduate Training Program, TU Dortmund)
	Winter Semester (2011-2012)	Qualitative Methods (Graduate Training Program, TU Dortmund)
	Winter Semester (2011-2012)	Qualitative Interview Seminar (Graduate Training Program, TU Dortmund)
	Summer/Spring Semester (2011-2012)	Questionnaire Analysis Seminar (Graduate Training Program, TU Dortmund)
	Summer/Spring Semester (2011-2012)	Case Study Research (Graduate Training Program, TU Dortmund)
	Summer/Spring Semester (2011-2012)	Comparative Case Study Analysis (Graduate Training Program, TU Dortmund)
	Summer/Spring Semester (2011-2012)	Transferability of Results (non-EU countries) (Graduate Training Program, TU Dortmund)
	Summer/Spring Semester (2011-2012)	Focus Group Discussion Methods (Graduate Training Program, TU Dortmund)
	Summer/Spring Semester (2011-2012)	MAXQDA Software (Graduate Training Program, TU Dortmund)
	Winter Semester (2013-2014)	PhD Workshop (improving access to restricted material) (Graduate Training Program, TU Dortmund)
	20.05.2014	PhD Colloquium presentation and feedback (Graduate Training Program, TU Dortmund)
	03.06.2014	Case study methods, presentation by Kathrin (ESR-08) (Graduate Training Program, TU Dortmund)
	08.07.2014	Networking meeting in Enschede for new Marie Curie ITN development with Marie (ESR-11), and Stefan Greiving (TUDO)
ESR12 Marie Charrière	14th September 2011, Barcelonnette, France	Inaugural Colloquium of the Research Centre Seolane
	28-29 November 2011, Lyon, France	Les Irisées 5 – Forum d'Infromation sur les Risques Majeurs – Education & Sensibilisation
	2nd July 2012, Marseille, France	1ère Rencontre Régionale de Prévention des Risques Naturels Majeurs
	16 December 2014, San Francisco, Usa	Careers in Science Writing
	17 December 2014, San Francisco, USA	Communicating Science to Society in the Face of Deep Unceertaincty and the Threat of manufactured Doubt Not Just the Facts: How to Communicate Opinion
	18 December 2014, San Francisco, USA	Practice Community Science : Hands-On Workshop The World Climate Game: What would a global climate change deal look like if you were a negotiator?
ESR15 Roya - Olyazadeh	15 – 16 Nov 2013,GEOMUNDUS, UJI, Castellón	Android platform development course
	7-13 Septembre FOSS4G 2014, Porltand, USA	Workshop on OpenSource Software , FOSS4G 2014 Portland
	GeoMundus, 7-8 November 2014,IFGI Germany	Mobile platform development course

9.9 List of participation in conferences and other scientific events, and attendance by ESR/ER and permanent staff

Name	Place / Period	Conference
Thea Turkington	07-09 March 2012 Kiel, Germany	End User Needs, VALUE 2012 Conference, attendence with poster presentation
	02-03 July, 2012	Young Researchers Forum, attendance with oral presentation
	03-06 July, 2012	GI Forum, attendance only
	15-19 December 2014, San Francisco, USA	American Geophysical Union Fall Meeting
Korbinian Breinl	17 nov – 18 Nov, 2011, Leipzig,Germany	FP7 ConHaz Final Synthesis Conference
	22-27 Apr, 2012, Vienna, Austria	EGU 2012
	2 Sep – 4 Sep, 2012, Vienna	Flood Symposium on climate change (TU Vienna)
	April 27-May 2, 2014, Vienna	EGU 2014
Romy Schlögel	7-8 September, Strasbourg, 2011 26-28 Janvier, Strasbourg, 2012 10 December, Strasbourg, 2012 07 – 12 April , Vienna, 2013 27-31 August, Paris, 2013 17-18 September, Grenoble, 2013 30 April – 3 May , Vienna, 2014 30 June – 1 July, Liège, 2014 9-10 September, Trondheim, 2014 18-19 November, Padua, 2014	JAG 2011 (Journées Aléa Gravitaire) JJG 2012 (Journée Jeune Géomorphologue Doctoral School Congress - 2012 EGU 2013 IAG 2013, JAG 2013 (Journées Aléa Gravitaire) EGU 2014 17th Joint Geomorphological Meeting, 2014 2nd Slope Tectonic Conference “Analysis and Management of Changing Risks for Natural Hazards” International conference
Ziga Malek	21-22 March 2012, Zürich, Switzerland	ECOCHANGE FP6 project Final conference, Poster presentation and land use change workshop attendance
	21 April 2012, Vienna, Austria	Mountain Research Initiative key contact Workshop, Research plan presentation
	30 May – 2 June, 2012 Stara Lesna, Slovakia	Forum Carpaticum, Science for the Carpathians Conference, Oral presentation
	24-26 October 2012, Vienna, Austria	IIASA 40th Anniversary Conference, Poster presentation
	28 February – 2 March 2013, Bonn, Germany	Hochgebirge im Globalen Wandel, Arbeitskreis Hochgebirge, 22. Jahrestagung 2013, Oral Presentation
	7 – 12 April 2013, Vienna, Austria	European Geosciences Union General Assembly 2013. Poster presentation
	19 – 21 March 2014, Berlin, Germany	2014 Global Land Project Open Science Meeting, “Land transformations: between global challenges and local realities”. Oral and poster presentation
	27 April – 2 May 2014, Vienna Austria	European Geosciences Union General Assembly 2014. Poster presentation
	23 – 26 June 2014, Bucharest, Romania	International Geographical Union – Commission on Land Use and Cover Changes 2014 Symposium: Land use-

		Land cover Changes and Land Degradation. Oral and poster presentation
	17 – 19 September, Darfo Boario Terme, Italy	International Scientific Committee on Research in the Alps (ISCAR) Forum Alpinum ’14. Poster presentation
	18 – 19 November, Padua, Italy	International Conference: Analysis and Management of Changing Risks for Natural Hazards. Oral presentation
Roxana Liliana Ciurean	22-27 April 2012, Vienna, Austria	European Geosciences Union General Assembly 2012. Oral presentation
	2-6, July 2012, Z_GIS, Center for Geo-informatics, University of Salzburg, Austria	GI-Forum 2012
	13 – 17 February 2013, London, UK	Workshop on The Dynamics and Impact of Interacting Natural Hazards
	7 – 12 April 2013, Vienna, Austria	European Geosciences Union General Assembly 2013. Poster presentation
	27 – 31 August 2013, Paris, France	International Conference on Geomorphology. Oral presentation
	27 April – 2 May 2014, Vienna Austria	European Geosciences Union General Assembly 2014. Oral and poster presentation
	18 – 19 November 2014, Padua, Italy	International Conference: Analysis and Management of Changing Risks for Natural Hazards. Oral presentation
	12 – 17 April 2015	European Geosciences Union General Assembly 2014. Poster presentation
Haydar Hussin	22-27 April, 2012, Vienna, Austria	EGU 2012
	2-6, July, 2012, Z_GIS, Center for Geo-informatics, University of Salzburg, Austria	GI-Forum 2012
	7-12 April 2013, Vienna, Austria	EGU 2013 (Attendance with poster presentation)
	16 June, 2013	GIT 2013– Oral Presentation, Chiavenna (Italy)
Veronica Zumpano	18 – 19 November, Padua, Italy	International Conference: Analysis and Management of Changing Risks for Natural Hazards. Oral presentation
	22-27 April, 2012, Vienna, Austria	EGU 2012 attendance with posters
	02-03 June 2012, Salzburg, Austria	Young Researchers' GIForum, attendance with presentation
	09-10 November 2012, Cluj Romania	20th edition of the “Geographic Information Systems” Symposium on Vulnerability And Risk Assessment Using G.I.S., attendance with presentation
Kathrin Prenger-Berninghoff	29-30 November 2011, Krakow, Poland	ESPON Climate Internal Seminar (Attendance with presentation, oral)
	12-15 May 2012, Bonn, Germany	**Resilient Cities 2012: 3rd Global Forum on Urban Resilience & Adaptation (Attendance with presentation, oral)**
	11-15 July 2012, Ankara, Turkey	AESOP 2012 (Attendance with presentation, oral, moderation of topical session)
	20-22 November, Rotterdam, The Netherlands	FLOODrisk 2012
Zar Chi Aye	4th November, 2011, Geneva, Switzerland	Workshop Risk Assessment, UNIGE (Attendance only)
	22-27 April, 2012, Vienna, Austria	EGU 2012 (Attendance with Poster

		presentation)
	2-3 July, 2012, Salzburg, Austria	YRF 2012 (Attendance with Oral presentation)
	20-22 November 2012, Rotterdam, The Netherlands	FLOODrisk 2012 (Attendance with Oral presentation)
	11-13 december 2012, Brussels, Beligum	ASEAN-EU 2012 (Attendance with Poster presentation)
	07-12 April, 2013, Vienna, Austria	EGU 2013 (Attendance with Poster presentation)
	15-16 Nov, 2013 Castellón de la Plana, Spain	Geomundus 2013 (Attendance with Oral presentation)
	27-05 May 2014, Vienna, Austria	EGU 2014 (Attendance with Poster presentation)
	18-20 June 2014, Chania, Greece	KES IDT 2014 (Attendance only)
	18-19 November 2014, Padvoa, Italy	CHANGES 2014 (Attendance with Oral presentation)
Vivian Juliette Cortes Arevalo	22-27 April, 2012, Vienna, Austria	EGU 2012,
	20-22 November, Rotterdam, The Netherlands	FLOODrisk 2012
	07 – 12 April 2013	EGU 2013 for the presentation of one Poster contribution, Vienna (Austria)
	16 June, 2013	GIT 2013– Oral Presentation, Chiavenna (Italy)
	27 April – 02 May 2014	EGU 2014 for the presentation of two Poster contributions, Vienna (Austria)
	15 June, 2014	GIT 2014 – Oral Presentation, Montefalco (Italy)
	New York, USA August 17 - 21, 2014	HIC 2014 _ 11th International Conference on Hydroinformatics & Informatics and the Environment: Data and Model Integration in a Heterogeneous Hydro World;
Teresa Sprague	10-13 October 2011, Brussels, Belgium	9th OPEN DAYS-European Week of Regions and Cities (Only attendance)
	29-30 November 2011	ESPON Climate Internal Seminar (Attendance with presentation, oral)
	11-15 July 2012, Ankara, Turkey	AESOP 2012 (Attendance with presentation, oral)
	16-20 July 2012, Oxford, UK	WaterDiss2.0 Summer Academy on Flood Risk Management (Attendance with presentation, oral)
	26-30 August, Cologne, Germany	IGC 2012 (Attendance with presentation, oral)
	20-22 November 2012, Rotterdam, The Netherlands	FLOODrisk 2012 (Attendance with presentation, poster)
	7-12 April 2013, Vienna, Austria	EGU 2013 (Attendance with presentation, oral)
	2-5 September 2014, Stockholm, Sweden	Stockholm World Water Week 2014
Marie Charrière	20-22 November 2012, Rotterdam, The Netherlands	FLOODrisk 2012
	13-14 December 2012, Enschede, The Netherlands	8th International Conference on Geo-Information for Disaster Management
	07-12 April 2013, Vienna, Austria	European Geosciences Union General Assembly
	04 December 2013 – 19 February 2014, Barcelonnette, France	“Alerte” exhibition
	27 April-02 May 2014, Vienna, Austria	European Geosciences Union General

		Assembly
	16-18 June 2014, Istanbul Turkey	23rd Society of Risk Analyis-Europe Conference
	13-17 October 2014, Nehoiu, Romania	Alerte” exhibition
	18-19 November 2014, Padova, Italy	International Conference Analysis and Management of Changing Risks for Natural Hazards
	15-19 December 2014, San Francisco, USA	American Geophysical Union Fall Meeting
Vera Andrejchenko	27.04.2014 - 02.05.2014, Vienna, Austria	EGU Vienna (Attendance with presentation, poster)
	24-27 June, Ohio, Columus	CVPR 2014
	17- 20 November .2014, Padova, Italy	CHANGES Final Conference (Attendance with presentation, poster)
Kaixi Zhang	27 April- 02 May 2014 , Vienna, Austria	EGU 2014
	18-19 November 2014, Padova, Italy	Analysis and Management of Changing Risks for Natural Hazards
Roya Olyazadeh	15-16 Nov, 2013 Castellón de la Plana, Spain	GeoMundus 2013 (Attendance with Oral presentation)
	27-05 May 2014, Vienna, Austria	EGU 2014 (Attendance with Poster presentation)
	18-20 June 2014, Chania, Greece	KES IDT 2014 (Attendance only)
	8-13 September 2014, Portland, USA	FOSS4G 2014 (Attendance and volunteer work)
	7-8 November 2014, Muenster,Germany	GeoMundus 2014 (Attendance with Oral presentation)
	18-19 November 2014, Padvoa, Italy	CHANGES 2014 (Attendance with Poster presentation)
Irina Cristal	14-16 November 2013, Castellón de la Plana, Spain	GeoMundus 2013 (Attendance)
	27 April – 02 May 2014, Vienna, Austria	EGU 2014 (Attendance with presentation)
	18 - 20 June 2014, Chania, Greece	KES 2014 (Attendance)
	13-18 July 2014, Barcelona, Spain	IFORS 2014 (Attendance with presentation)
	07-08 November 2014, Munster, Germany	GeoMundus 2014 (Attendance with presentation)
	18-19 November 2014, Padua, Italy	CHANGES final conference (Attendance with presentation)
Julian Berlin	27 April- 02 May 2014 , Vienna, Austria	EGU 2014 (Attendance with Poster presentation)
	18-19 November 2014, Padova, Italy	Analysis and Management of Changing Risks for Natural Hazards (Attendance with Poster presentation)