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Knowledge sharing among and within stakeholder groups to cope with climate related risks.

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My contribution is specified in a footnote at the beginning of each chapter, no specification means I am entirely responsible for the research described in the chapter, which for chapters 2 to 5 (included) was carried out under the supervision of Carlo Giupponi; specific contributions in published work are described for each in the list of published work.

Specific contributions are also acknowledged at the end of each publication. Last but not least I would like to thank Dave Huitema and Stefan Kienberger who were the two members of the reading committee: they revised two complete drafts of the thesis and gave feedback to improve it.

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List of acronyms

AM analysis matrix
CCA climate change adaptation
CM cognitive map
CONRED Coordinadora Nacional Reduccion de Desastre
CSM creative system modelling
CSO civil society
DPSIR Driving force – Pressure – State – Impact – Response
DRR disaster risk reduction
DSS Decision Support System
ED Exogenous Drivers
ENG-LAND Engineering Solutions and Land Management
FCM fuzzy cognitive map
FEEM Fondazione Eni Enrico Mattei
GAM gap analysis matrix
GDM group decision making
GO governmental organization
GOV-INST Investments in Governance and Institutional Strength
IIT Integrated Indicator Table
IPCC Intergovernmental Panel on Climate Change
IWRM Integrated Water Resources Management
KNOW-CAP Knowledge Improvement and Capacity Building
LA local actor
MCDA Multi Criteria Decision Analysis
MCA Multi Criteria Analysis
mDSS Mulino DSS
NetSyMoD Network Analysis, System Analysis, Creative System Modelling, Decision Support
NGO non-governmental organization
PLANNING Planning instruments
SES social-ecological system
SH stakeholder
TCM total cognitive map
UBRB Upper Brahmaputra River Basin
UDRB Upper Danube River Basin
UNFCCC United Nations Framework Convention on Climate Change

ABSTRACT

In this PhD thesis methods for operationalizing climate change adaptation (CCA) are explored. The thesis is structured around methods to develop tools for knowledge integration and management, and for participatory processes. The methodologies developed are tested using relevant case studies. Three are the main results:

1. the Integrated Indicator Table (IIT) useful to establish a biunivocal relation between research outcomes and stakeholders' needs in the field of integrated water resources management;
2. the Gap Analysis Matrix (GAM) useful to identify governance and policy gaps in the law and its implementation with respect to flood risk;
3. the Total Cognitive Map (TCM) useful to collect and analyse visions stakeholders have on risk and disaster risk reduction (DRR), and to identify and improve possible synergies among institutions and organizations dealing with DRR.

Two paradigms, which are becoming more and more relevant in CCA, are taken into consideration, and case studies are developed in relation to them. The first paradigm is Integrated Water Resources Management (IWRM) and the case study used to explore and develop a methodology is the research project BRAHMATWINN. The second paradigm is Disaster Risk Reduction (DRR) and the case study is identified based upon a knowledge integration process taking place in Guatemala.

Three phases of the research carried out during the project BRAHMATWINN (FP6) are described in this thesis, as this is a case study for which methodologies for adaptation to climate change have been explored and developed further.

In a first step two parallel processes have been designed and implemented: (1) the identification of the potential supply of scientific knowledge through the development of a system of indicators proposed by BRAHMATWINN project partners, and (2) the elicitation of local actors' (LA) issues and proposed response strategies. Integrated indicators were developed with relevance to IWRM and climate change for the Upper Danube and the Upper Brahmaputra River Basins (UDRB and UBRB), and to foster the integration process amongst the different research activities of the project. Such integrated indicators aim at providing stakeholders, non-governmental organizations and governmental organizations with an overview of the present state and trends of the river basins water resources, and at quantifying the impacts of possible scenarios and responses to driving forces, as well as pressures from climate change. In the process the relevant indicators have been identified by research partners to model and monitor issues relevant for IWRM in the case study areas. The selected indicators have been validated with the information gathered through the NetSyMoD approach in workshops with LAs, and stored in an Integrated Indicators Table (IIT). In this way a link between the main issues affecting the basins as perceived by LAs and the BRAHMATWINN activities has been created, thus fostering integration between research outcomes and local needs.

In a second step a participatory process was carried out to identify responses for sustainable water management in a climate change perspective, in the two river basins UDRB and UBRB. The methodology implemented through local participatory workshops, aimed at eliciting and evaluating possible responses to flood risk, which were then assessed with respect to the existing governance framework. The main outcome of such activities consists in the identification of Integrated Water Resource Management Strategies based upon the issues and preferences elicited from local experts. The Mulino Decision Support System tool (mDSS) was used to facilitate transparent and robust management of the information, the implementation of multi criteria decision analysis, and the communication of the outputs. The outcomes of the implementation of the proposed methods and mDSS tool are discussed to assess the potential to support decision-making processes in the field of CCA and IWRM.

Finally an analysis was carried out in order to identify governance gaps with respect to response strategies to cope with the expected impacts of climate change in the field of water resources management. An innovative approach based on the analysis of gaps in the governance status with specific focus on response strategies options, which can be implemented to address flood risk was implemented. A GAM was created for the identification of gaps within the governance framework by elaborating further on the contents of the IIT: governance indicators developed within the BRAHMATWINN project were now elaborated further to measure the law and its implementation. The

synthesis of this GAM should be a list of recommendations for IWRM through the identification of potential gaps in government water resource management policy.

The idea explored in the Guatemalan case study is to use cognitive maps to define a method to enable synergies and define roles and measures for disaster risk reduction (DRR) and climate change adaptation (CCA). Stakeholders in this research are government organizations, non-governmental organizations, and civil society, who have a mandate for -or a stake in- DRR and CCA. Cognitive maps are created through an online questionnaire. Fuzzy cognitive mapping algorithms are used to compare, analyse and synthesize the concept of risk as perceived by a group of stakeholders. CM are used to identify disaster risk reduction measures and relative roles institutions should have to enable the exploitation of synergies. A total cognitive map is then created including all opinions elicited, and then specific cognitive maps are derived from it to exemplify possible uses.

Key words: participatory process; knowledge integration; climate change adaptation; flood risk; decision support system; evaluation of responses; integrated water resources management; IWRM; disaster risk reduction; DRR; Mulino decision support system, mDSS; Pajek; FCMapper; cognitive map; BRAHMATWINN; Guatemala.

1. CHAPTER 1
INTRODUCTION AND FRAMEWORKS OF REFERENCE

1.1. Introduction

1.1.1. Climate change adaptation

According to the Fourth Assessment Report released by IPCC in 2007, the climate has been changing over the last decades and will continue to change even if greenhouse gas emissions are reduced to meet the targets of the Kyoto Protocol (IPCC, 2007a; Mace, 2005). The environmental, social and economic costs of extreme weather events are already rising in both poor and rich countries. Climate change impacts are expected to be unevenly distributed across the planet and some areas, like mountains covered by glaciers and tropical areas, will be subjected to major stresses (Stenseth et al. 2002).

Projected climate changes for the 21st century in the mountains of the world is two to three times greater than the change observed in the 20th century (Nogues-Bravo et al., 2007). All mountains are expected to warm, but warming will vary with location. Depending on which IPCC-SRES scenario (IPCC 2000) is considered, in 2055 mid-latitude mountains of Asia have a projected temperature increase between 2.7°C and 3.8°C, while mid-latitude mountains of Europe have a projected temperature increase between 2.3°C and 3.3 °C (Nogues-Bravo et al., 2007). However, assessing impacts of this temperature change is not so straightforward because of non-linear feedbacks between impacts and because of uncertainty in the downscaling of Global Circulation Models (Nogues-Bravo et al., 2007

There is evidence based on observations that glaciers have been retreating and decreasing in volume, and that mountain snowpack is also decreasing. As a consequence the water storage capacity of the mountains has been decreasing over time (Nogués-Bravo et al., 2007; Stewart, 2009). The hydrologic cycle is, thus, changing and more dramatic changes are expected up-stream and down-stream (Nogués-Bravo et al., 2007), with summer droughts which might last longer (Stewart, 2009), and have a decreased water availability especially when lowlands are arid (Messerli et al., 2004; Viviroli et al., 2007), as is the case of systems like the Himalayas (Viviroli and Weitgartner, 1999; Messerli et al., 2004). Though physically distant from each other, the populations of different parts of the world will be facing similar problems, such as water shortage.

Precipitations increased significantly in some regions of the world, among them Central America (IPCC 2007a). Not many studies have been carried out to describe climate in Guatemala. A workshop organized in November 2004 in Guatemala sheds some light on observed climate change in Central America and Northern South America using observed data from over 100 meteorological stations, four of which in Guatemala (Aguilar et al. 2005). Looking at observed climate in the past 40 years in Central America there are signs of warming average and extreme temperatures; also changes have happened in precipitation patterns: positive and negative trends are found in the different locations observed (Aguilar et al. 2005).

Moreover, among the countries in the world which will be most hardly hit we find Guatemala. As is shown in data considering the mortality risk index for multiple risks Guatemala is one of the countries with highest number of people killed (PreventionWeb[1]). Considering human exposure to land slide risk (Figure 1) Guatemala is in the sixth rank according to absolute figures, but the first five nations have considerably larger populations, and is in the fifth rank if we consider population at risk as percentage of total population.

[1] http://www.preventionweb.net/english/maps/index.php?cid=70

Human Exposure

Modelled number of people present in hazard zones that are thereby subject to potential losses.

Absolute human exposure

	Average people exposed per year	Country
1	197,372	Indonesia
2	180,254	India
3	121,488	China
4	110,704	Philippines
5	64,470	Ethiopia
6	48,698	Guatemala
7	48,116	Mexico
8	37,030	Japan
9	30,624	Colombia
10	28,504	Nepal
11	24,960	Myanmar
12	17,730	Taiwan, prov. of China
13	16,632	Peru
14	16,146	Brazil
15	15,050	Comoros

Relative human exposure

	Countries	%	People exposed per year, percentage
1	Dominica	2.6	
2	Comoros	1.8	
3	Réunion	1.7	
4	Martinique	0.5	
5	Guatemala	0.4	
6	Saint Lucia	0.3	
7	Papua New Guinea	0.2	
8	Solomon Islands	0.2	
9	Mauritius	0.2	
10	Bhutan	0.2	
11	Costa Rica	0.1	
12	Fiji	0.1	
13	Philippines	0.1	
14	El Salvador	0.1	
15	Sao Tome and Principe	0.1	

Figure 1. human exposure to land slide risk (PreventionWeb[2])

[2] http://www.preventionweb.net/english/hazards/statistics/risk.php?hid=65

According to the Stern Review (Stern, 2006), it is no longer possible to prevent the climate change that will take place over the next two to three decades, and adaptation to climate change is therefore essential to protect our societies and economies from its impacts. Poor and developing countries in particular, which are only marginally responsible for anthropogenic climate change, will be the most affected by the expected impacts (Heltberg et al., 2009; Thomas and Twyman 2005). Climate change is therefore also an equity issue and adaptation policies should continue to have a role in international negotiations and scientific research (Mace, 2005).

Adaptation has been on the agenda since the Earth Summit in Rio (1992) and reference to adaptation can also be found in the United Nations Framework Convention on Climate Change (UNFCCC, 1992) and the Kyoto Protocol (1997). According to UNFCCC Annex II, countries that ratified the convention made a legally binding commitment to fund adaptation in developing countries (www.unfccc.int; Mace, 2005). However, it is not until the Marrakech Accords (2001) that adaptation policies and projects have gained importance (Schipper, 2006) and in the Fourth Assessment Report of the IPCC (2007a), as well as in the Stern Review (2006), we find reference to a demand for research on adaptation, mitigation, and development. Adaptation policies, however, can be very challenging, and negating their right importance would imply strengthening inequalities, thus burdening those countries and those sectors that will bear the heaviest impacts of climate change, such as water provisioning in river basins fed by glacier melt (Mace, 2005).

1.1.2. Social-ecological system: Integrated Water Resources Management, and Disaster Risk Reduction

Climate change adaptation is necessary to reduce vulnerability of the Social-ecological system (SES) (IPCC 2011; Smit and Wandel 2006). Adaptation and vulnerability in the context of this research are defined according to UN-ISDR definition. Many and varied are, in fact, the definitions given for each, and it is out of the possibilities of this research to analyse in detail what many have already done through a very deep and time-consuming effort (Janssen 2007; Janssen et al. 2006). Adaptation is defined as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities[3]". Vulnerability is defined as "The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard[4]".

There is a strong interconnectedness between the human and the natural sphere (Janssen and Ostrom 2006). Anthropogenic disturbances are increasing ecosystems vulnerability (du Toit et al. 2004; Janssen and Ostrom 2006). Increased vulnerability of ecosystems makes them prone to further crisis, such as natural climatic variances like El Niño (Curran et al. 2004). Global change will most likely exacerbate these conditions (IPCC 2007).

Regime shifts in ecosystems –as described by Scheffer (Scheffer 2001; Scheffer and Carpenter 2003)- make ecosystems alternate between different states. Climate variability is one of the drivers of these shifts (Scheffer 2001), and there is wide consensus that climate change will increase climate variability (IPCC 2007). Understanding the drivers of these changes is important for adaptation purposes.

Each SES can be defined through a set of variables, relating to elements that characterize the system itself (Walker et al. 2004). Due to the complexity of the human-environment interaction the approach will have to be interdisciplinary (Janssen and Ostrom 2006). Governance and ecosystem processes have to be investigated as linked systems in a multidisciplinary approach, at the appropriate scale (Agrawal and Ostrom 2006). Local ecological knowledge and modern science have to be used to conserve the environment (du Toit et al. 2004).

In his seminal paper Holling (1973) describes ecosystems as dynamic rather than stable systems. Ecosystems alternate between different states; however, humans tend to describe the alteration of an ecosystem as a crisis (Holling 1973). Holling (1973) first used the term resilience in ecology, defined as "the measure of these systems to absorb changes of state variables, driving variables, and parameters, and still persist."

Applying the concept of resilience to management of natural resources in general implies consciousness about ecologic processes, awareness of the possibility of unexpected events happening, and a continuous learning experience approach (Holling 1973). Management of SESs will

[3] http://www.unisdr.org/we/inform/terminology

[4] http://www.unisdr.org/we/inform/terminology#letter-v

have to be multiple-scale, thus it will have to be the result of interaction among all stakeholders (Walker et al. 2004; Bengtsson et al. 2003).

Managing SESs will have to incorporate uncertainties, and proceed through a trial and error methodology (Janssen and Ostrom 2006; Bengtsson et al. 2003; Gunderson 2000). Due to unstable states of ecosystems, managing should, in fact, be a learning process, i.e. adapting management to different states (Gunderson 2000; Olsen and Christie 2000). Variability of natural processes and changes in anthropogenic drivers imply that management plans have to be continuously monitored, evaluated, and adapted to the changing conditions. The advantages offered by adaptive management in comparison with conventional management include learning from experience and feedback, recognition of alternatives and trade-offs, and the possibility of long-term goals (Berkes et al. 2000).

Either adaptability or transformability will have to be incorporated in the management process. Adaptability –“the capacity of humans to manage resilience”- has to do with the four phases through which SESs cycle: (i) growth and exploitation, (ii) conservation, (iii) collapse and release, (iv) reorganization (Walker 2004). Transformability is “the capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable” (Walker et al. 2004).

Adaptive capacity is context specific, thus it varies in different places or communities (Smit and Wandel 2006). Adaptation measures will, thus, be the result of interactions among all local actors (LA), including local communities (Bengtsson et al. 2003; Agrawal 2000). Local communities can provide knowledge which is the results of long-term observations (Drew 2005), and long-term monitoring capabilities needed for management (Agrawal 2000; Berkes et al. 2000). They must be considered managers, not only users (Agrawal 2000; Berkes et al. 2000). Moreover the impacts of climate change are felt in specific places, therefore the local stakeholders have to be included in the decision making process (Tompkins and Adger 2004).

In this context, Integrated Water Resources Management (IWRM) is one of the most popular paradigms adopted by legislation and plans in many parts of the world (GWP, 2000). The success of this paradigm is due to the recognition of the need to deal with the impacts of climate change on water resources in a holistic manner. Generally speaking, in fact, when dealing with the social-ecological system, it is often impossible to cope with one impact without affecting the other elements of the system: therefore the solutions are best sought in a holistic framework (Folke et al., 2005). Moreover, since the impacts are felt in a variety of sectors, and the result is bigger than the mere sum of the single impacts, responses can be developed in an integrated manner (Heltberg et al., 2009). Considering specifically water the IPCC acknowledges the fact that climate change will impact water availability, for example because of a reduced flow in watersheds fed by glaciers or snowmelt, which is the situation of the case studies presented in this thesis (IPCC, 2007b). Water scarcity sparks conflicts, which some think might be better addressed in an IWRM setting, where conflicting uses can find a compromise solution (World Water Council, 2006).

Another paradigm of reference gaining increasing attention is Disaster Risk Reduction (DRR; see IPCC 2011). In addressing impacts of climate there has been a paradigm shift towards risk management and prevention rather than being limited to emergency response, i.e. the attention is focusing on coping strategies and proactive measures (Tadesse et al. 2008). Moreover, often there is an overlap of resources and projects to reduce risk, some aim at climate change adaptation (CCA), others at DRR: integrating the two approaches would improve effectiveness (Gero et al. 2011). To define this paradigm and promote a common understanding UN-ISDR published a glossary[5] with terminology in use, taken as reference in this thesis.

This paradigm requires the spatial and temporal determination of who is at risk, which should be based on diverse information, such as climate data, agricultural data, and socio-economic data (Tadesse et al. 2008). These data are the outcomes of research carried out within several scientific disciplines. Moreover, there is another source of information, which should be included: indigenous and local knowledge (IPCC 2011). The added value of including indigenous and local knowledge is two-fold. On the one hand, what is called scientific knowledge is at times based upon some indigenous and local knowledge observations. There is now ground to say that scientific and indigenous and local knowledge are both related to the development of research: “an understanding of the coevolution of science, society, and environment that shows why these are not really contradictions at all should be the future goal of the anthropology of the environment” (Dove 2006, pag.203).

[5] http://www.unisdr.org/we/inform/terminology#letter-d

On the other hand, indigenous and local knowledge can help when research is not available for a specific place. What indigenous and local peoples have, in fact, is the understanding of local specificities, which might overcome scientific knowledge gaps. Some populations have accurate ways to predict weather based on observations of natural phenomena in their surroundings. It is the case of the Andes, for example, where local people look at the brightness of the Pleiades to forecast the coming rain season, and then based on this decide when to sow potatoes. Combining approaches of anthropology and climate science Orlove et al. (2000) were able to demonstrate that there is, in fact, a scientific base for this prediction: climate science explains and confirms local observations used to predict weather and decide when to sow potatoes are correct, moreover these observations are also a good way to predict El Niño Southern Oscillation. Both communities, the scientific and the indigenous, could benefit from information sharing: climatologist will be pointed to specific clues and thus will be able to disclose mechanisms, local people might learn how to improve their skills (Orlove et al. 2000).

Other studies can be useful for expanding our overview to other observations that led to early action, decrease risk, and, most importantly, number of casualties. An example is the research carried out by Baumwolle (2008) on Simeulue (Indonesia) and the 2004 tsunami. During interviews to assess whether indigenous knowledge can be/has been used for DRR, high levels of indigenous knowledge, which are related to both how to forecast a tsunami, and to what needs to be done when tsunami is forecast, were found where the least number of casualties were counted (Baumwolle 2008). However, these kinds of studies highlight not only the importance of indigenous knowledge, but also its necessity (Twomlow et al. 2008; Shukla & Sinclair 2010).

Two caveats at this point need to be expressed. The first is that proving such direct connection between indigenous and local observations -and relative management decisions- and science is not always easy (e.g. Patt et al. 2005). The second is that sometimes even if peoples have knowledge some other factor prevails and decisions taken are not the best possible ones. Such is the case of Mbow et al. (2008) who describe the drivers which lead to settle in a dangerous location.

The rhetoric of community natural resources management is powerful, but at times its implementation is difficult (Kellert and Mehta 2000). Kellert and Mehta (2000) suggest that success depends on institution building and public education. For communities to be involved in the managing process stakeholder agency in risk governance has to be acknowledged (Larsen et al. 2011).

Thus, the concept of “adaptive co-management”, defined by the Resilience Alliance as “combining the iterative learning dimension of adaptive management and the linkage dimension of collaborative management in which rights and responsibilities are jointly shared” bears much interest. The term “adaptive” has a high significance. Starting from John Dewey’s “learning-by-doing” concept (1909), up to more recent studies (e.g. Pahl-Wostl 2007) the importance of integrating lessons learned from experience into management is fundamental.

The identification of “adaptive co-management” as a framework of reference seems the most fitting to address the issue as defined. According to Olsson et al. (2004) adaptive co-management is based on scientific and local knowledge, sharing of power and responsibilities, capacity building of local communities for monitoring, cooperation and coordination among existing institution, but also new institutions might be needed and created. A comprehensive understanding of the system is generated by the combination of traditional knowledge from individuals and communities and scientific knowledge, for example local ecological knowledge can enable early awareness of change in ecosystem processes, thus early warning and action (Olsson et al. 2004). Ultimately the commons can be governed when information at the appropriate scale is provided to all, alternative options are analysed and, thus, conflicts decreased, physical and technological infrastructure is provided, change is taken into account (Dietz et al. 2003).

The participation of stakeholders can contribute significantly, in fact, to the achievement of project outcomes that are better suited to fulfil society’s needs (de La Vega-Leinert et al., 2008), thus increasing the impacts of research efforts. They further mutual learning between scientists and stakeholders, new opinions can be expressed, problems can be addressed, technical expertise shared, agreements reached, and compromise solutions found if all vested interests are voiced (Renn, 2006). Stakeholders’ involvement is essential, because stakeholders hold the necessary information that could facilitate the exploitation of scientific knowledge with high social relevance (de La Vega-Leinert et al., 2008; Griffin, 2007; Reed, 2008). Participatory processes can be of many kinds and defining what is the goal of the participatory process is necessary before identifying the most suitable approach for the given case (Irvin and Stansbury, 2004).

As a means to facilitate public participation in the field of adaptation to climate change, there is an increasing attention to the need for efficient tools to support the management of those processes and the role that could be played by information and communication technologies, mathematical simulation models and Decision Support System (DSS) tools, in particular. In the context of climate change research the first category of tools may provide scientifically-based scenarios and projections – prerequisites for any planning activity - while DSS tools may provide the ground for bridging the scientific contributions (i.e. by further elaborating model outcomes) and decision/policy-making processes, including managing the participation of different actors (e.g. policy makers, local experts, dwellers, etc.) in a scientifically sound and transparent way.

Despite the theoretical potential, traditional modelling techniques have shown limited impacts on policy-making, especially with respect to complex systems such as those involved in natural resource management. DSS tools have quite often performed similarly. One of the problems most often mentioned is the limited or late involvement of stakeholders and potential users (Geurts and Joldersma, 2001), which contributes significantly to the limited uptake of modelling tools and outcomes. The conventional division of roles between the academy and 'outsiders', where scientists supply conceptual frameworks, theories, methods which are then available for use by various actors in society, such as politicians, civil society, etc., is not accepted anymore (Scott Cato, 2009) and new relationships between science, politics and society are necessary.

1.1.3. Methods

Two approaches will be used as reference in the thesis to implement what outlined above: NetSyMoD and Cognitive Maps, which will be briefly described in **Paragraph 1.1.4** and **Paragraph 1.1.5.**

Features of these two methods make them fit for the research goals of this thesis, which are based on stakeholders' participation, knowledge identification, sharing, and integration, and include the development of easy to use tools. These methods are, in fact, useful to enable a participatory setting in which stakeholders can collaborate and establish a dialogue, highlighting commonalities and differences among visions they have. Nevertheless, involving stakeholders in a participatory process may require too much time and resources, in relation to budgetary and time constraints. The chosen methods instead have given interesting results in other researches, and match the availability I have of funding and time. Moreover, decision support systems enable dealing with different disciplines towards the definition of a common framework, as well as with the uncertainties each of these disciplines has in defining outcomes.

Ultimately this thesis is not about defining one best practice or comparing methods, but rather, given the opportunities identified introduced in **Paragraph 1.2**, about exploring possible methods to operationalize climate change adaptation paradigms testing some possible methods, i.e. evaluating and exploring these methods in hands-on experiences, namely those offered by the BRAHMATWINN research project (**Chapter 2** to **Chapter 5**) and by the Guatemalan knowledge harmonization process (**Chapter 6**). Thus, it is not possible to compare the different methods and tools developed and implemented, but only to assess their usefulness with respect to the satisfaction stakeholders themselves have expressed, i.e. the potential benefit the implementation of such methods and tools could have for the design of climate change adaptation plans and measures. Usefulness in the context of this research therefore means that the methods and tools have been well accepted by the stakeholders involved in the process, and could possibly be adopted by other stakeholders, e.g. practitioners dealing with IWRM and DRR. Usefulness is, in fact, measured only through stakeholders' direct comments and feedback about the possibility that they might in the future make use of the methodologies by themselves.

1.1.4. NetSyMoD

The framework of reference used in the BRAHMATWINN research project (see **Paragraph 1.2.1**) is based on the NetSyMoD methodology (Giupponi et al., 2008) for the management of participatory modelling and decision processes (Figure 2). NetSyMoD stands for Network Analysis – Creative System Modelling – Decision Support, more information can be found on the website[6] here I will only briefly describe the relevant phases for the thesis, a more detailed methodology will be discussed in the relevant chapters.

The framework is organised in six main phases. The first three (*Actors' Analysis*, *Problem Analysis*, *Creative System Modelling*) provided the BRAHMATWINN Project with (1) an in depth analysis of general problems related to water resources management in the two upper river basins, with the participation of the communities of interested parties in the case study areas, and (2) mental model representations of the problems, i.e. qualitative descriptions of the causal links between the various

[6] http://www.netsymod.eu/

components of the local socio-ecosystems by means of cognitive maps clustered in order to be consistent with the DPSIR framework (Driving forces, Pressures, State, Impacts, and Responses; EEA, 1999; Borja et al., 2006), used as an upper – aggregated – level communication interface. These phases were carried out by colleagues who worked under the supervision of Carlo Giupponi, and whose contribution I would like to acknowledge, because it laid the foundation for my research.

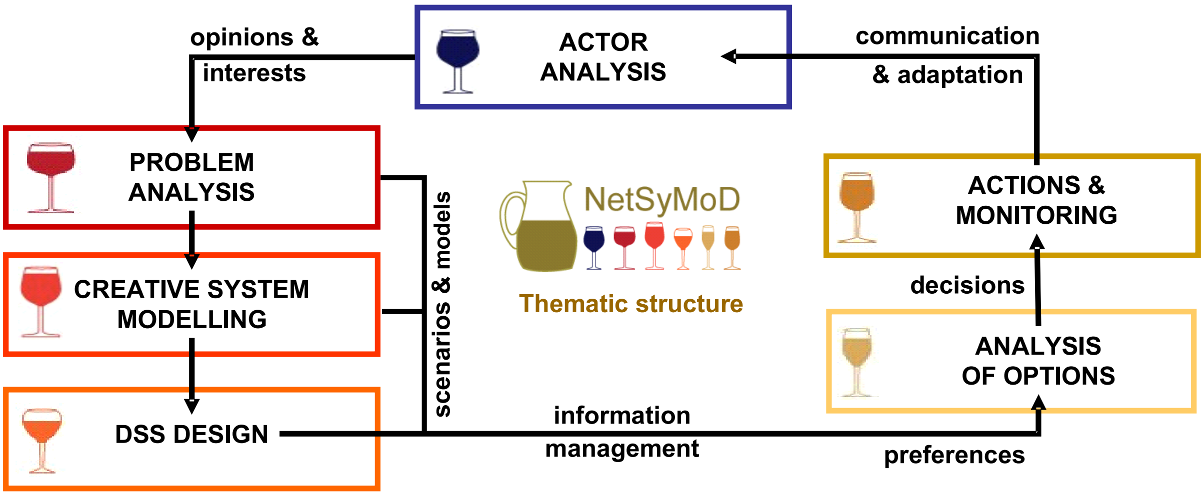

Figure 2. The NetSyMoD flowchart: an approach for participatory modelling and decision making

The subsequent phases, *DSS Design* and *Analysis of Options*, were the object of the activities carried out at the three workshops described in this thesis, and contributed to the design and evaluation of a set of alternative responses obtained with group elicitation techniques and with the application of the DSS tool. The last phase, *Actions and Monitoring*, is beyond the scope of the research project.

The *DSS Design* phase consists of system specification and development of software tools capable of managing the data required for informed and robust decisions. The *Analysis of Options* is performed with the Mulino DSS software (mDSS) through Multi Criteria Decision Analysis (MCDA), which provides a framework for decision analysis, and with a set of techniques aiming at the elicitation and aggregation of decision preferences (Figueira et al., 2005). In this case, MCDA demonstrates how to assist a decision maker, or a group of decision makers, in identifying the best alternative from a range of alternatives in an environment of conflicting and competing criteria and interests (Belton and Stewart, 2002). The MCDA was carried out under the supervision of Carlo Giupponi by my colleague Lucia Ceccato and me.

1.1.5. Cognitive maps

Cognitive maps are graphs used to represent causal chains and knowledge (see for example Novak and Cañas. 2008). Cognitive maps as an aid for the description of concepts and causal chains that link them are quite often used for many different scopes (e.g. Kosko 1986; Ozesmi & Ozesmi 2004). Additionally Kosko (1986) has explored the possibility of defining, i.e. weighting, the causal relationship between two nodes, i.e. concepts, creating fuzzy cognitive maps (FCM).

> "FCM are fuzzy-graph structures for representing causal reasoning. Their fuzzyness allows hazy degrees of causality between hazy causal objects (concepts). Their graphs structure allows systematic causal propagation (…). FCMs are especially applicable in soft knowledge domains (e.g. political sciences…) where both the system concepts/relationships and the meta-system language are fundamentally fuzzy." (Kosko 1986:65)

In a FCM each concept identified is represented as a node of the map, and causal chains or linkages are represented as connections between two nodes (Kosko 1988; Ozesmi & Ozesmi 2004). Drawing FCM allows for the exploration of possible causal chains and feedback among nodes, representing, thus, interactions among elements of the social-ecological system. Additionally the strength of each connection, and whether the effect is positive or negative, is expressed by a real number [-1, 1]. Each FCM can also be represented by a square symmetric matrix, where the value 0 is attributed when there is no connection between two nodes, and a value [-1, 1] is attributed when there is a causal link between two nodes. FCM have had application in several cases for the management of the social-ecological system (Hobbs et al. 2002; U. Ozesmi & S. L. Ozesmi 2004; Kok 2009; van Vliet et al. 2010; Stylios et al. 1997; Salerno et al. 2008).

1.2. Case studies

1.2.1. BRAHMATWINN

Having recognised the relevance of the issues briefly discussed above, the BRAHMATWINN research project[7] has planned a participatory process to integrate scientific and stakeholders' knowledge to deal with water management, climate change in Alpine regions of Europe and Asia. For this purpose, a programme of local workshops in two twinned river basins, the Upper Brahmaputra and the Upper Danube (UBRB and UDRB, respectively), has been defined in parallel to the more common research activities in the various disciplinary fields (dynamic climatology, hydrology, sociology, economics, etc.) relevant for the integrated assessment of climate change impacts and the development of adaptation strategies. The integration of the two research streams allowed the project to facilitate the dissemination of results of scientific, data-driven analyses regarding the drivers of change on the river socio-ecosystems and related impacts on the one hand and, on the other, to orient and consolidate those investigations according to the feedback collected through the involvement of local actors (LAs)[8].

The project was carried out through the collaboration of an international research consortium of European and Asian institutions and it focused on two –"twinned"– river basins in the two continents: the Danube and the Brahmaputra. The choice of these study areas stemmed from the idea, later confirmed by the research results, that the two upper river basins, even if very distant from geographical and socio-economic viewpoints, would have commonalities, since they are both fed by glaciers potentially impacted by climate change. This hypothesis was confirmed during the project, which showed how climate change scenarios downscaled for the case studies (Dobler et al., 2010), point out how intensified weather events in both areas are expected to cause an increase in rainfall in the wet season and of droughts during the dry periods. Climate change could thus exacerbate the uncertainty of water availability and quality, and the occurrence of extreme events, as BRAHMATWINN climatologists have suggested.

For the purposes of the project, five case studies have been analysed: two in the Upper Danube River Basin (Danube) - the Lech River Basin and the Salzach River Basin (Austria and Germany) - and three in the Upper Brahmaputra River Basin (Brahmaputra) - the Assam State of India, the Wang Chu River Basin (Bhutan) and the Lhasa River Basin (Tibet, China).

The Fondazione Eni Enrico Mattei (FEEM) research group – to which I belong – developed, under the supervision of Carlo Giupponi, a methodological proposal aimed at strengthening the communication and collaboration within the research consortium and with local communities of the end users of project outcomes. This process enabled exchange of knowledge and feedbacks between the twinned river basins, and among scientists and LAs. A programme of local workshops in the two river basins was thus defined in parallel to the other research activities in various disciplinary fields (dynamic climatology, hydrology, sociology, economics, etc.) relevant for the integrated assessment of climate change impacts and the development of adaptation strategies.

1.2.2. Guatemala

The starting point for the research carried out in Guatemala was an ongoing project on knowledge integration for DRR called "La cosmovisión de los pueblos de la humanidad en la construcción social del conocimiento para la RRD y ACC" that is implemented by CARE, an international NGO, and is financed by PSO, a Dutch NGO that has the objective of financing learning processes within Dutch development programmes. This project is part of a wider global project: "Sub-programme 2 Integration of knowledge and experiences from indigenous/local, technical, and scientific spheres".

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[7] www.brahmatwinn.uni-jena.de/

Project title: Twinning European and South Asian River Basins to enhance capacity and implement adaptive management approaches. (BRAHMATWINN). Project no: GOCE -036952. Research funded by the European Community, SUSTDEV-2005-3.II.3.6: Twinning European/third countries river basins.

[8] We have preferred to use the term local actor (LA), to identify all the people involved in the case study activities instead of the more commonly used term stakeholder, to emphasise the fact that they were people who did not belong to the project consortium (typically local experts or policy makers), involved in project activities by partners responsible for the management of case studies to provide advice and steer project activities, without the ambition to assess their representativeness with robust procedures, such as Social Network Analysis.

During the implementation process in Guatemala, representatives of different governmental and non-governmental institutions that are promoting the rights of the indigenous peoples have emphasized the importance that a governmental institute should facilitate the process. Due to its national responsibilities regarding DRR, Secreteria Ejecutiva Coordinadora Nacional Reduccion de Desastre (SE-CONRED, Secretariat of the national Coordinator for Disaster Reduction)took the responsibility to facilitate the process which led to the creation of the "Comisión para la armonización de los conocimientos y sabidurias de los pueblos Maya, Xinca, Garifuna y Mestizo ante la reducción de riesgo a desastre", hereafter Comisión (Commission for the harmonization of knowledge and experiences from Maya, Xinca, Garifuna, Mestizos). The following national institutes participate in the Comisión: SE-CONRED, Ministerio de la Educacion (MINEDUC, Ministry of Education), Ministerio de Ambiente y Recursos Naturales (MARN, Ministry of Environment and Natural Resources), Ministerio de Agricultura, Ganaderia y Alimentacion (MAGA, Ministry of Agriculture and Food Security), Secretaria (SESAN, Secretariat for food security).

The opportunity of being part of this process seemed like a good chance to gain insights on on-the-ground work linking CCA to DRR.

1.2.3. Relevance of case studies

I developed my idea starting from BRAHMATWINN: during this research I was able to develop methodologies for knowledge integration, and for interaction among and within different groups, i.e. researchers and LAs. During the BRAHMATWINN research, which is described in **Chapter 2** to **Chapter 5**, I was able to design and implement a process, which is constituted by the following elements:

- **Chapter 2** sets the framework describing preliminary phases of the project: the design of a knowledge integration framework to integrate interdisciplinary research outcomes (i.e. integration within research partners), and to guide researchers in addressing needs of LAs (e.g. end-users, such as policy makers and local administrations);
- **Chapter 3** describes the analysis of effectiveness of identified response measures to cope with impacts of climate change, namely flood risk, with the aid of a decision support system freeware, namely mDSS;
- **Chapter 4** further analyses and defines response strategies through the involvement of LAs in the definition and selection of actions to implement the response measure selected previously (in **Chapter 3**);
- **Chapter 5** concludes the BRAHMATWINN research by identifying governance gaps, and by proposing recommendations for the improvement of IWRM to better cope with impacts of climate change.

The research described in these chapters was carried out in collaboration with other colleagues at FEEM. The outcomes of BRAHMATWINN opened the possibility of further research built upon a process taking place in Guatemala for knowledge integration as a way to improve DRR and to enable synergies among GOs, NGOs, and CSOs: **Chapter 6** describes the methodology developed to define:

- how risk is identified/perceived by stakeholders belonging to different cultures and/or institutions;
- what the differences and similarities among these perceptions are;
- how these perceptions can be integrated to create a shared understanding and enable synergies among GOs, NGOs, and CS who have a mandate for DRR.

In **Chapter 7** conclusive remarks and needs for further research are identified.

1.3. Research overview

1.3.1. Major objectives

Having defined the overarching theme (i.e. climate change adaptation), the paradigms of reference (i.e. IWRM and DRR), after the identification of case studies were a hands-on experience could be carried out with respect to these three, and taking advantage of my background and knowledge, now the definition of major objectives can take place. The definition of objectives, in fact, in the context of this research is a "needs based" effort, i.e. the definition of objectives relevant for the case studies, as identified by stakeholders, is what drives the research. This strengthens the need for a participatory and inclusive process, as well as the importance of the knowledge elicitation from relevant stakeholders. The two opportunities outlined above resulted in the following research objectives:

1. how to develop a needs driven research approach where potential end-users of results identify issues they have mandate to deal with, and responses, existing or needed, to cope with these issues;
2. how to evaluate the effectiveness of the different alternative responses identified in coping with the local issues;
3. how to improve the governance framework by defining recommendations to design, implement, and/or develop responses;
4. how to adapt to climate change enabling synergies within a governance framework, and building on each stakeholder's knowledge and roles.

1.3.2. Research outcomes

The first three objectives were built into the research carried out within BRAHMATWINN; main outcomes in relation to them are:

1. the design of a table to enable matching of research results, i.e. the Integrated Indicator Table, where indicators identified and defined by the researchers, were put in a biunivocal relationship with issues and responses identified by the local actors; iterative phases to compile the table were carried out among researchers and local actors, and this enabled researchers to address issues relevant for local actors;
2. multi-criteria analysis was used to assess response effectiveness in dedicated workshops were local actors first chose and weighted criteria, and then used these to evaluate response effectiveness; preferences expressed by single participants were imported in a decision support system freeware called mDSS to rank responses and analyse group preferences; the results were reported at the end of each workshop to local actors, who validated them through a final discussion, and through feedback written on specifically designed forms;
3. the information collected from researchers and from local actors relevant for the governance pillar was used to identify gaps in the governance framework: analysing these gaps recommendations for the improvement of governance were suggested;

The fourth point was based on the opportunity offered in Guatemala by the ongoing knowledge harmonization process for disaster risk reduction and climate change adaptation:

4. stakeholders belonging to three groups (i.e. government organizations, non-government organizations, and civil society organizations) were identified, mainly selecting those involved in or by the Comisión, and they were asked to share their visions on risk and disaster risk reduction; these visions were analysed using cognitive mapping techniques and synthesized in a comprehensive –total- cognitive map, which is then used to create cognitive maps for a specific risk or organization, and, thus, to define synergies by identifying roles and mandates of single organizations.

1.3.3. Chapters overview

CHAPTER 2. THE INTEGRATED INDICATORS TABLE: LINKING RESEARCH OUTCOMES AND LOCAL ACTORS' NEEDS

Definition of the structure for the Integrated Indicators Table used to organize: (1) knowledge outcome of research, and (2) knowledge elicited in consultations with local actors during workshops. The hierarchical structure facilitates matching of the two kinds of knowledge in a biunivocal relationship, enabling researchers to address local actors' needs, and local actors to improve their understanding of research outcomes.

CHAPTER 3. ANALYSIS OF THE EFFECTIVENESS OF RESPONSE STRATEGIES TO DEAL WITH FLOOD RISK UNDER THE IMPACTS OF CLIMATE CHANGE

A methodological proposal aimed at improving the effectiveness of interactions between the scientific community and local actors for decision-making processes in water management was developed and tested to two case studies, in Europe and South Asia: the Upper Danube (UDRB) and Upper Brahmaputra (UBRB) River Basins. The general objectives of the case studies were about identifying and exploring the potential of adaptation strategies to cope with flood risk in mountain areas. The proposal consists of a sequence of steps including participatory local workshops and the use of a Decision Support Systems (DSS) tool. Workshops allowed for the identification of four categories of possible responses and a set of nine evaluation criteria, three for each of the three pillars of sustainable development: Economy, Society and the Environment. They also led to the ranking of the broad categories of response strategies, according to the expectations and preferences of the workshop participants, with the aim of orienting and targeting further activities by the research consortium. The DSS tool was used to facilitate transparent and robust management of the information, the implementation of Multi-Criteria Decision Analysis and the communication of the outputs. The outcomes of the implementation of the proposed methods and DSS tool are discussed to assess the potential to support decision-making processes in the field of climate change adaptation (CCA) and Integrated Water Resources Management (IWRM).

CHAPTER 4. DESIGN OF RESPONSES BASED ON "PLANNING" TO DEAL WITH FLOOD RISK IN A CHANGING CLIMATE

Building on the information and preferences developed during BRAHMATWINN as a result of the interaction among researcher and local actors a final process of validation and further specification of responses is organised. A workshop was, thus, specifically designed to take place in Kathmandu during the final BRAHMATWINN meeting in November 2009. After the presentation of BRAHMATWINN's outcomes local actors had the possibility of expressing their views first in a brainstorming phase to define possible actions to be implemented in the framework of IWRM based on planning, i.e. the preferred response category according to the previous workshop in the region (Kathmandu 2008), and then give input for the multi-criteria analysis, i.e. weighting the selected criteria, and scoring the effectiveness of responses using an analysis matrix. Using mDSS the information was analysed and a final ranking of what actions could be implemented was produced using the group decision making capabilities of mDSS.

CHAPTER 5. IMPROVING WATER GOVERNANCE THROUGH SCIENCE AND STAKEHOLDER DIALOGUE: EXPERIENCE FROM ASSAM (NORTHEAST INDIA)

In this chapter we describe some outcomes and follow-up developments of the European project BRAHMATWINN. In particular, we describe the analyses carried out in order to identify the governance gaps in the response strategies developed to deal with the expected impacts of climate change in the field of water resources management. We use an innovative approach, which can be implemented to address flood risk, based on the analysis of gaps in the governance status with specific focus on response strategies options. An Integrated Indicators Table (IIT) is proposed for the integration of scientific and local knowledge. The IIT provides the groundwork to identify the gaps between the existing legal framework and real life needs. The ultimate goal of this approach is to support a process that develops recommendations aimed at strengthening the governance framework in order to deal with the impacts of climate change. First of all, two parallel processes have been designed and implemented: (1) the identification of the potential supply of scientific knowledge through the development of a system of indicators proposed by the BRAHMATWINN project partners, and (2) the elicitation of local actors' issues and proposed responses to cope with these issues. Indicators and issues/responses are then matched in a framework, the IIT, which highlights the needs for the research approach and integrates the outcomes of the BRAHMATWINN researchers. Extracting knowledge linked to governance from the IIT a Gap Analysis Matrix (GAM) is then created to identify the gaps within the governance framework: the qualitative governance indicators developed within the BRAHMATWINN project are now elaborated further to measure the law and its implementation. The synthesis of this GAM is a list of recommendations for Integrated Water Resources Management, which address the identified potential gaps in government water resource management policy.

CHAPTER 6. EXPLORING SYNERGIES FOR DISASTER RISK REDUCTION IN GUATEMALA: THE USE OF COGNITIVE MAPS

The idea explored in this research is to use cognitive maps (1) to compare, analyse and synthesize the concepts of risk and disaster risk reduction as perceived by three groups of stakeholders, namely government organizations, non-government organizations, and civil society organizations, and (2) to identify and design disaster risk reduction measures, and to define roles institutions should have to enable the exploitation of synergies. An online questionnaire, created with Qualtrics, is designed to gather information, then FCMapper is used to create adjacency matrices and net files, and finally Pajek is used to draw the cognitive maps using the net files (all are freely available on the internet). Analysis and synthesis of cognitive maps is carried out, and as a result one total cognitive map is drawn by adding the single adjacency matrices. Further elaborations of cognitive maps give as a result specific cognitive maps, which are useful for the definition of organizations' roles and mandates with respect to disaster risk reduction.

CONCLUSIONS

A final chapter provides some general conclusions of the research carried out during the three years of my PhD.

2. CHAPTER 2
THE INTEGRATED INDICATORS TABLE: LINKING RESEARCH OUTCOMES AND LOCAL ACTORS' NEEDS[9]

2.1. Framework

One of the responsibilities I had within the BRAHMATWINN was to develop integrated indicators with relevance to IWRM and climate change for the Upper Danube and the Upper Brahmaputra River Basins (UDRB and UBRB), and to foster the integration process amongst the different activities of the project. Such integrated indicators aim at providing stakeholders, NGOs and GOs with an overview of the present state and trends of the river basins water resources, and at quantifying the impacts of possible scenarios and responses to driving forces, as well as pressures from likely climate change. In the process the relevant indicators have been identified by partners to model and monitor issues relevant for IWRM in the case study areas. The selected indicators have been validated with the information gathered through the NetSyMoD approach (Giupponi, C. et al., 2008) in Creative System Modelling (CSM) workshops elicited from stakeholders. Therefore they are useful for, but are not limited to, the description of the concepts mainly elicited in the stakeholder's workshops carried out so far in the UBRD and the UDRB. In this way a strong link between the main issues affecting the basins as perceived by LAs and the BRAHMATWINN partners' activities is created, which will foster the implementation of IWRM practices, the evaluation of their effectiveness and the development of new strategies to cope with the changing conditions. This chapter describes the development of a set of integrated indicators to support the above mentioned processes, and to cover the environmental, social, economic, and governance spheres relevant for the project study areas.

For this purpose the structure of the integrated indicators table (IIT) was defined in agreement with the consortium. The set of integrated indicators is designed as a multilevel list, a tool for integrated assessment. FEEM has coordinated the collection of indicators among partners, and allocated the indicators collected in hierarchical levels, a consistent structure for modelling activities. The structure in which the indicators are organised is composed of four categories: **Themes – Domains – Sub-domains – Indicators**.

The **Themes** aim at characterising a sustainability framework, and are:

- *Environmental:* describe the state of the natural environment. Environmental indicators provide information about complex, typical or critical processes between human and natural systems, and simplify communication about the issues addressed (EEA, 2005). These indicators characterise physical, biological or chemical aspects or dynamics of systems helping decision makers in solving problems and developing new policies;
- *Social*: this category guarantees that the Human Dimension is described by the set of indicators developed. The domains pertaining to this category are, for instance, gender, livelihoods and assets, health and sanitation;
- *Economic*: include the human economic activities, such as production and employment;
- *Governance*: describe the legislative and institutional frameworks, including the degree of public participation, education and awareness of a population (Allan A., and A. Rieu-Clarke, 2007a).

Research activities within the BRAHMATWINN project were many and varied, they fall within different disciplines, and they make use of various models and assessment frameworks. As a consequence, a significant number of indicators and data sets are required to populate the different models and approaches, which can complicate both the identification of key overarching issues and the communication of the results, as well as the understanding of the underlying modelling framework on behalf of non-experts. To overcome some of these problems and facilitate the identification of integrated IWRM indicators and of intra-disciplinary linkages, within this project we have adopted the terminology of **domain** to identify a particular environmental, social, economic or governance issue (e.g. Climate Hazards, Biodiversity, Human Health, Waste, Land, Water, Gender…). **Sub-domains**

[9] OTHER DESCRIPTIONS OF THE FRAMEWORK OF THE ITT HAVE BEEN PUBLISHED IN:

Giannini, V., and Giupponi, C. (2011) Improving water governance through science and stakeholder dialogue: experience from Assam (Northeast India). CMCC Research papers RP0115.

Giannini, V. and Giupponi, C. (2011) Integration by identification of indicators, Adv. Sci. Res., 7, 55-60, doi:10.5194/asr-7-55-2011.

have also been defined, for the identification of more specific categories of issues addressed by groups of –site specific- detailed indicators. For instance the domain “climate” could be subdivided into four sub-domains: “precipitation”, “temperature”, “aridity” and “evapotranspiration”, each of them quantified by one or more indicator. The adoption of this framework should simplify the task of exploring the data provided by the different models used in BRAHMATWINN, as well as help researchers to compare and communicate the project’s results in a concise but meaningful manner.

The IIT, however, as any classification has some limitations and rigidity. One example is the classification of “Vulnerability” within the Environmental theme. Vulnerability has been defined in many ways, and BRAHMATWINN project partners Z_Gis and GeoDa have written a background paper which is the reference for this project. However, the IIT is useful to integrate the results of research coming from the different disciplines represented.

2.2. The collection of indicators

2.2.1. Population of the IIT

The choice of the set of indicators is carried out keeping in mind that it should meet the needs and priorities of users (e.g. policy and decision makers, experts, civil society groups) in monitoring processes towards the implementation of IWRM principles in the Upper Danube and Upper Brahmaputra River Basins. The collection of all indicators used by, or relevant to, partners is the first phase planned for the development of a set of integrated indicators. Therefore, indicator profile forms (not described in this thesis, please refer to BRAHMATWINN Deliverable 6[10]) have been prepared and distributed among the BRAHMATWINN partners to be filled with information relative to each indicator they have identified. The template used to define each indicator’s profile is divided into three different sections:

1) *general information about the indicator*: requires providing the main information about the indicator (e.g. name, definition, domain of applicability);
2) *rationale for indicator selection:* aims at collecting synthetic information on the choice of the particular indicator in relation to its usability;
3) *data needs*: aims at collecting information on data needs and data availability for the indicator.

The brief descriptions of each indicator provided are also presented in the same Deliverable 6. The task of each partner was to suggest a way of measuring through indicators the list of domains provided in the forms. All indicators have been selected because of their policy relevance, with respect to climate change and water resources management, availability of historical time series, data availability over a large part of the UDRB and UBRB and transparency (i.e. they can be easily understood by the policy-makers and the general interested public). The information collected defined a list of indicators, organised according to the domains and sub-domains of reference in the common framework described above, and for further evaluation within the consortium. In this way the results from the precedent phases of research (Deliverable 2[11], Deliverable 3[12], Deliverable 4[13]) are integrated. Socio-economic indicators have been identified and applied at the local scale in Deliverable 4, where a review was carried out to identify *key indicators* for the practical assessment and development of *vulnerability* profiles for the Brahmaputra river basin case studies[14]. The review was further aimed at identifying potential data sources and indicators for analysing climate hazard and vulnerability. The whole study also incorporated local residents’, stakeholders’ and experts’ knowledge in the analysis of vulnerability to climate hazards and led to a vulnerability mapping exercise.

For the catchment of the Salzach river basin Z_GIS derived spatial vulnerability units which can serve as an integral part to delineate integrated Hydrological Response Units. The hazard type “flood” has been chosen to serve as a starting point to develop the methodology, which defines vulnerability within the context of a certain hazard type (e.g. floods, drought, …). The overall vulnerability consists of different domains, such as susceptibility, adaptive and social capacity, and resilience. For each

[10] http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_6.pdf
[11] http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_2.pdf
[12] http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_3.pdf
[13] http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_4.pdf
[14] For more details please refer to the BRAHMATWINN sub-DL 4.5 “*Mapping the multi-dimensions of socio-economic vulnerability to climate hazards in the Upper Brahmaputra River Basin: An Actor based approach*” by GeoData Institute, University of Southampton; and the Concept paper , part of the Dl_4.5 entitled “*Defining vulnerability. Towards a conceptual model for climate change impact*” by GeoData Institute, University of Southampton and Z_GIS, Salzburg.

domain, sub-domains have been identified and relevant indicators and data sources established[15]. Also within Deliverable 4 another report has been produced that, on the basis of a literature review, examines the “gendered nature of potential vulnerabilities” of immediate and long-term consequences of water-related hazards and disasters linked to processes of climate change, with specific reference to the region that extends from the Tibet Autonomous Region of China where it originates, to Bhutan and Assam (India) in the UBRB.

Governance indicators have been identified for the UDRB and the UBRB by the University of Dundee in the Deliverable 4 “*Identification of the Legal and Policy Framework in Upper Brahmaputra and Danube River Basins*”. The indicators proposed are defined as questions allowing conclusions to be drawn about both the adequacy of the governance framework in the context of climate change events, and the degree to which implementation of that framework is successful (Allan A. and Rieu-Clarke A., 2007b).

Other indicators have been developed within Deliverable 2 in which the downscaling of Global Climate Models predictions have been carried out, and within Deliverable 3, which foresees the assessment classification and quantification of the components of the natural environment such as topography, climate, hydrology, snow and glacier cover, permafrost and slope stability, land use and land cover, soils and geology, sediments and erosion, water quality, eco-hydrology and biodiversity from the Natural Dimension.

The framework is presented in Table 1, and the complete list of indicators included in Table 2 and Table 3, in Table 4 and Table 5 opinions expressed by LAs are found.

The consolidation of the draft list of indicators provided should lead to the development of a set of indicators, which represent a preliminary list, that could later be expanded or compressed. The hierarchical structure allows for flexibility, having different measures according to the different case study areas:

- Lech River Basins, Austria and Germany;
- Salzach River Basin, Austria and Germany;
- the State of Assam, India;
- Lhasa River Basin, Tibet Autonomous Region, PRC;
- Wang Chu River Basin, Bhutan.

The diversity of each case study area is taken into account at the level of sub-domains through different sets of indicators, which are relevant for each area. On the other hand, models provide mainly quantitative information, while governance indicators are completely qualitative. The list of sub-domains constitutes the interface between stakeholders opinions and researchers outputs: it is at this level that the integration process between them takes place.

2.2.2. Integration and validation of IIT

Three rounds of interaction among project partners were planned for the development and validation of the IIT. The first is above described and was carried out by distributing a template for the collection of the indicators from each partner. The following two, here described, resulted in the validation of the IIT by the project partners.

The second round of interaction among project partners consisted in a gap analysis. Confronting the indicators selected by the partners with the concepts expressed by the stakeholders, a gap analysis has been performed to verify whether the partners have provided indicators suitable to address, quantify, and describe the issues identified by the stakeholders. When no indicator within the list provided by partners corresponds to an issue or response strategy as expressed by stakeholders, a gap is identified, which should be filled by the partners. This gives information about the appropriateness of the set of indicators proposed to describe problems at the local scale. The consolidation of a list of concepts vs. indicators couples will enable and validate the partners’ research outcomes (analysis and modelling) with the opinions provided by the stakeholders, describing with more detail the needs and issues they have to cope with at the local level. This process allows for the integration of the analysis (both within the human dimension and the natural environment) carried out in the previous phases of the project’s implementation in a common framework, which will serve to support the decision making process, as a base for the evaluation of different alternative options, carried out later through the application of the mDSS software.

[15] For more details on this study refer to the sub-DI_4.5 “*Vulnerability Mapping in Danube River Basin test area (Salzach River)*” prepared by Z_GIS, Salzburg.

For instance, at the level of domains no indicators have been provided by partners to monitor migration and demographic patterns under the “Social” Theme, “Natural Hazards” under the “Environmental” Theme, “Waste Management” and “Transportation” under the “Economic” Theme, and “Capacity building”, “Decision Making”, and “International Cooperation” within the “Governance” Theme.

At the level of sub-domains more gaps can be found. What happens here is that there is a mismatch between the indicators and the issues, meaning that indicators could not be useful in measuring those issues that relate to the common sub-domain. This is the case with “Gender”, where, for example, no indicator is given to describe the unequal access to natural resources by females and males. Also activities which are the result of economic development, such as “Increased quarrying” and “Industrial development” are not described by partners through indicators. Lastly, “Awareness”, clearly identified as a central element by stakeholders involved in the CSM workshops, for the improvement of water resources management has no corresponding indicator in the list given by partners.

Another type of gap is that concerning the use of dams for energy production. In this case, the indicators chosen by partners lack of specific parameter definition to measure the impact on the environment of the construction and management of dams, which was valued as relevant by stakeholders.

With the third round of interaction among project partners the IIT was validated. It must be said, however, that the IIT must not be thought of a rigid and definitive table, but more of a flexible structure within which indicators can be added or modified according to research needs and new findings.

The creation of the IIT enabled then merging of two processes, one stakeholder/end-user driven, and the other researcher driven. The framework (theme, domains, sub-domains) can thus be seen as the interface between the contributions of stakeholders and BRAHMATWINN project partners towards the formalization of the problem. Sub-domains represent the level we have decided to deal with in future steps of the project, because they represent the complexity of the system at a level of definition stakeholders and end-users can deal with.

The IIT was then used in two workshops (Salzach, October 2008; Kathmandu, November 2008) giving the possibility to stakeholders to give feedback on it, and then in the concluding symposium (Kathmandu, November 2009) where stakeholders made a final validation of it.

2.2.3. The allocation of indicators to the DPSIR framework

The set of indicators was also clustered in the DPSIR framework (EEA, 1999). Each sub-domain has been allocated to one of the components of the DPSIR framework. This was done in coherence with the brainstorming exercise carried out with stakeholders, where mental maps were created, with reference to the DPSIR framework (refer to Table 1).

“Precipitation” and “Temperature” sub-domains have been allocated to a node defined as “External drivers”. This has been done in accordance with the fact that the BRAHMATWINN project deals with local adaptation strategies, and the intervention on these two sub-domains relates more to mitigation strategies.

The 49 sub-domains have been associated to each of the nodes. However, it is evident that the allocation can never be definitive, as it is difficult at times to perform. Sub-domains have been allocated as following:

- EXOGENOUS DRIVERS (ED): 2 sub-domains
- DRIVING FORCES (D): 12 sub-domains
- PRESSURES (P): 12 sub-domains
- STATE (S): 11 sub-domains
- IMPACT (I): 4 sub-domains
- RESPONSE (R): 8 sub-domains

All 8 sub-domains relative to the “Governance” theme have been allocated to the “Response” node, to stress the importance of the idea that through governance IWRM response options can be developed and implemented, as will be discussed in **Chapter 3**, **Chapter 4**, and **Chapter 5**.

Table 1. IIT frame work and DPSIR allocation

Theme	Domain	Sub-Domain	ED	D	P	S	I	R
Environmental	Basin description	Basin morphology				1		
	Ecosystem /Biodiversity	Ecosystem functions				1		
		Biodiversity				1		
	Land use / Land use change	Land use				1		
		Glaciology				1		
		Permafrost				1		
	Forests	Forest management				1		
	Water	Water quality				1		
		Water resources pressure			1			
		Water resources state				1		
		Water resources impact					1	
		Water flow				1		
	Climate	Precipitation	1					
		Aridity					1	
		Evapotranspiration				1		
		Temperature	1					
	Environmental hazards	Vulnerability					1	
Social	Livelihoods/ Assets	Poverty		1				
		Water availability		1				
		Education /Information		1				
	Population	Population dynamics		1				
	Gender	Gender issues		1				
	Community structure	Age distribution		1				
	Health/ Sanitation	Morbidity and mortality					1	
		Sanitation system			1			
		Healthcare delivery			1			
	Settlements	Housing settlements			1			
		Urban settlements			1			
	Infrastructure	Access to infrastructure			1			
		Road infrastructure		1				
		Water infrastructure		1				
		Infrastructure pressures			1			
Economic	Wastes	Waste management			1			
	Energy	Energy consumption			1			
		Energy production			1			
	Economic development	Agricultural production			1			
		Service sector		1				
		Construction sector			1			
		Industrial production		1				
		GDP/GNP		1				
		Employment		1				
Governance	Education	Capacity building						1
		Increase knowledge						1
	Institutional and legislative frameworks	Decision making						1
		Public Participation						1
		Disaster preparedness						1
		IWRM /NRM						1
		General institutional and legislative frameworks						1
	International relations	Transboundary issues						1

Table 2. Project partners' contribution to the IIT (part 1 of 2)

Theme	Domain	INDICATOR	unit	partner	ED	D	P	S	I	R	Sub-Domain
Environmental	Basin description	Aspect	%	FSU				1			Basin morphology
		Basin area	km2	FSU							
		Length-breadth-ratio of basin	ratio	FSU							
		Slope	%	FSU							
		Topographic gradient	m	FSU							
		Topographic wetness index		FSU							
		Aspect/slope (elevation)	degree/ %	ZGIS							
	Ecosystem /Biodiversity	Ecoregions	classes	UniVie				1			Ecosystem functions
		Ecosystem Services	classes: low-medium-high	UniVie							
		Conservation Significant	Area/%and number	ICIMOD							
		Biodiversity	low-medium-high	UniVie				1			Biodiversity
	Land use / Land use change	Land use	%	FSU				1			Land use
		Ecosytem function (Land use Land cover Change)	Area/%	ICIMOD							
		Area [m2] per Land Use/Land Cover Class (7/20; depending on level)	km2/class	ZGIS							
		Snow cover: difference between years 2000-2006	normalized value	ZGIS							
		Glacier inventory: change between 1968 and 1998; absolute values for each year	km2/class	ZGIS				1			Glaciology
		Glaciated area percentage	%	UniOslo							
		Glaciated area hypsography	km2 / 100 m (or 50m)	UniOslo							
		Upstream glacier contribution	km2 and km	UniOslo							
		Permafrost area [km2]	km2	ZGIS				1			Permafrost
		Permafrost area hypsography	km2 / 100 m (or 50m)	UniOslo							
		Permafrost area percentage	%	UniOslo							
	Forests	Forest area [m2] per 1000m grid cell	m2/grid cell	ZGIS				1			Forest management
		Forest land - decline in	%	IIT-R							
		Afforestation (planned)	km2, %	ZGIS							
		Afforestation (spontaneous, bush encroachment)	km2, %	ZGIS							
		Forestland		GeoDa							
		Forest cover area & its temporal changes	ha & %	IIT-R							
	Water	Number of water extraction & discharge	Number	ZGIS				1			Water quality
		Water quality	Categories	ZGIS							
		Contamination of ground water	mg / l	IIT-R							
		Water supply	%	FSU			1				Water resources pressure
		Renewable rate	Mio.m3	FSU							
		Total water extraction	Mio.m3/a	FSU							
		Amount of water resources in typical, wet and dry years	Mio.m3	FSU				1			Water resources state
		Water reservoirs	%	FSU							
		Wetland (beel)	ha	IIT-R							
		Lake area [m2] per 1000m grid cell	m2/grid cell	ZGIS							
		Retention area [m2] per 1000m grid cell	m2/grid cell	ZGIS							
		Percentage of extracted water to total water resources in typical, wet and dry years	%	FSU					1		Water resources impact
		Relative water stress index (RWSI)	na	FSU							
		Discharge	m3/a; m3/sec	FSU				1			Water flow
		Dominant type of runoff generation	%	FSU							
		Drainage density	Ratio/ %	FSU							
		Form factor (Horton)	ratio	FSU							
		Water level exceedance	m or m3/s	FSU							
		Monthly discharge (12 mean monthly discharge values per year and catchment outlet)	qm/s	LMU							
		Annual runoff pattern	mm/a	LMU							
	Climate	Annual precipitation	mm	FSU	1						Precipitation
		Areal precipitation	mm/km2	FSU							
		Precipitation trend	%	FSU							
		Annual rainfall pattern	mm/a	LMU							
		Yearly precipitation	mm/a	JWG							
		Monsoon length	days	JWG							
		Monsoon onset	date	JWG							
		Seasonal precipitation	mm/season	JWG							
		Precipitation frequency	l	JWG							
		Heavy precipitation threshold	mm/day	JWG							
		Max. 5-day precipitation	mm	JWG							
		Average precipitation intensity	mm/day	JWG							
		Longest dry period	days	JWG							
		Heavy precipitation proportion	l	JWG							
		Heavy precipitation days	l	JWG							
		Aridity index		FSU					1		Aridity
		Potential evapotranspiration	mm/d	FSU				1			Evapotranspiration
		Evapotranspiration (annual pattern)	mm/a	LMU							
		Average annual temperature	°C	FSU	1						Temperature
		Extreme temperature indices	°C, %, days	ITP							
		Annual mean temperature	°C	JWG							
		Growing season length	days	JWG							
		Growing season onset	date	JWG							
		Seasonal mean temperature	°C	JWG							
		Hot-day threshold	°C	JWG							
		Cold-day threshold	°C	JWG							
		Frost days frequency	l	JWG							
		Longest heatwave	days	JWG							
	Environmental hazards	Percentage of population living in flood risk areas	%	FSU					1		Vulnerability
		Potential floodplains	% and/or km2	FSU							
		Ecohydrological Vulnerability	low - high	UniVie							
		Potential erosion prone stream bank line	Km	IIT-R							
		Plain form index (PFI) & its spatio-temporal changes	ratio	IIT-R							
		Peak Ground Acceleration 10% probability of exceedance in 50 years	%	ZGIS							
		Avalanche risk	Categories	ZGIS							

Table 3. Project partners' contribution to the IIT (part 2 of 2)

Theme	Domain	INDICATOR	unit	partner	ED	D	P	S	I	R	Sub-Domain
Social	Livelihoods/ Assets	Asset ownership	proportion	GeoDa		1					Poverty
		Per capita income	Rupees	IIT-R							
		Income	proportion	GeoDa							
		Public Distribution System (PDS)	Rs.(000)	IIT-R							
		Population with access to public water supply	%	FSU		1					Water availability
		Distance to water (potable)	km	FSU							
		Gross per capita water availability (PCWA)	m3/person/year	FSU							
		Water consuming sectors	%	FSU							
		Water accessibility and water quality	proportion	GeoDa							
		Drinking water - sources of	users/100 people	IIT-R							
		Number of residents non-academics per 1000m grid cell	No./grid cell	ZGIS		1					Education /Information
		Drop-out	number	IIT-R							
		General & adult literacy	% of population	IIT-R							
		Access to information and communication facilities (radio, television, telephone, etc.)	No./pop	GeoDa							
	Population	Population density	Inhabitants/km2	FSU		1					Population dynamics
		Population growth rate	%	FSU							
		Population		FSU							
		Urbanization		GeoDa							
		Population within 10km of coastline or flood plain		GeoDa							
		Distance to river bank		GeoDa							
		Settlements on river banks	km2	ZGIS							
	Gender	Sex ratio	ratio	GeoDa		1					Gender issues
		Gender - Female literacy	%	IIT-R							
		Female income		GeoDa							
		Income inequality		GeoDa							
	Community structure	Number of population aged < 20 per 1000m grid cell Number of population aged 20 - 80 per 1000m grid cell Number of population aged > 80 per 1000m grid cell	no/grid cell	ZGIS		1					Age distribution
	Health/ Sanitation	Infant mortality	%	IIT-R					1		Morbidity and mortality
		Maternal mortality	%	GeoDa							
		Incidence of malaria and water borne diseases		GeoDa							
		Life expectancy		GeoDa							
		Sanitation	proportion	GeoDa			1				Sanitation system
		Sanitation	%	IIT-R							
		Proximity [km] to health facilities per 1000m grid cell	km/grid cell	ZGIS			1				Healthcare delivery
		Distance to nearest health service	km;	GeoDa							
	Settlements	Number of residential buildings per 1000m grid cell	no/grid cell	ZGIS			1				Housing settlements
		Housing	proportion	GeoDa							
		Housing	%	IIT-R							
		Number of cities larger than 100 000 inhabitants		FSU			1				Urban settlements
		Share of population in cities over 100.000	%	FSU							
		Urbanization		ICIMOD							
	Infrastructure	Proximity [km] to primary roads per 1000m grid cell	km/grid cell	ZGIS			1				Access to infrastructure
		Length [m] of primary roads per 1000m grid cell	m/grid cell	ZGIS		1					Road infrastructure
		Road density	proportion	GeoDa							
		Inland navigation share of cargo transport	%	IIT-R		1					Water infrastructure
		Amount/kind of water infrastructure (e.g. dams, reservoirs)		GeoDa							
		Flood damage to property, man , cattle-head	Rupees, No.	IIT-R			1				Infrastructure pressures
		Reservoir Induced Seismicity (RIS)	N/A	IIT-R							
		Chance of occurrence of dam break	% chance	IIT-R							
		Likely stream bed retrogression downstream	Metre	IIT-R							
		Reservoir sedimentation volume & submergence area	CuM, Hectare	IIT-R							
Economic	Wastes	Number of waste disposal & treatment	Number	ZGIS			1				Waste management
	Energy	Energy Balance	Terajoule per district	ZGIS			1				Energy consumption
		Per capita utilization		IIT-R							
		Number of big dams >15m	Number	FSU			1				Energy production
		Number of small dams <15m	Number	FSU							
		% of big dams used for water supply, hydropower and both	% of all big dams	FSU							
		% of small dams used for water supply, hydropower and both	% of all small dams	FSU							
		Biomass - type of fuel used	%	IIT-R							
	Economic development	Livestock density	Livestock/km2	FSU			1				Agricultural production
		Irrigated area for Kharif crop	%	FSU							
		Irrigated area for Rabi crop	%	FSU							
		Commercial agricultural land (in km2) per 100 household	km2 per 100 household	GeoDa							
		Grain yield and consumption		ICIMOD							
		Cropping patterns - Agricultural income	Rs(000)	IIT-R							
		Horticulture crop density	ha	IIT-R							
		Irrigated Land	%	IIT-R							
		Kharif land - crop diversity	Acre	IIT-R							
		Homestead garden	ha	IIT-R							
		Tea growing area	hectare	IIT-R							
		Fish catch in a year	Kg	IIT-R							
		Trade and service sector - growth of	%	IIT-R		1					Service sector
		Development of land	%; km2	ZGIS			1				Construction sector
		Industrial development	%; km2	ZGIS		1					Industrial production
		Industry		ICIMOD							
		Annual Industrial Growth Rate	%	IIT-R							
		GDP		ICIMOD		1					GDP/GNP
		GNP		ICIMOD							
		Number of full time employees (male & female) per 1000m grid cell	No./grid cell	ZGIS		1					Employment
		Number of labours in the agriculture sector per 1000m grid cell	No./grid cell	ZGIS							
		Number of workplace with < 49 employees per 1000m grid cell	No./grid cell	ZGIS							
		Employment rate	proportion	GeoDa							
		Economic alternatives	km	GeoDa							
		Labour		ICIMOD							
		Employment structure		ICIMOD							
Governance	Education	Conduct of training programmes & short-term course	No. of training & trainees	IIT-R						1	Capacity building
		Environmental information	N/a	UnivDu						1	Increase knowledge
		IWRM information	N/a	UnivDu							
		IWRM information exchange	N/a	UnivDu							
		Stakeholders participation in decision making	N/a	UnivDu						1	Public Participation
		Citizens consultation actively sought	N/a	UnivDu							
		Stakeholders participation in water and flood management	N/a	UnivDu							
		Early Warning System available per 1000m grid cell	No./grid cell	ZGIS						1	Disaster preparedness
		First responders	km	ZGIS							
		Emergency plan for flood & erosion mitigation	N/A	IIT-R							
		Availability of risk zones and laws	Categories	ZGIS							
		Raised platform construction in rural areas	No./village clusters	IIT-R							
		IWRM extent	N/a	UnivDu						1	IWRM /NRM
		IWRM climate change obligations	N/a	UnivDu							
		Flood risk planning	N/a	UnivDu							
		Effective emergency alleviation	N/a	UnivDu							
		Flood risk: water and land use planning	N/a	UnivDu							
		Stream-bank erosion control plan	N/a	IIT-R							
		Rights to information	N/a	UnivDu						1	General institutional and legislative frameworks
		Civil society access to redress and remedy	N/a	UnivDu							
		Constitutionality of laws	N/a	UnivDu							
		Checks and balances on government	N/a	UnivDu							
		Enactment of consolidation of land holdings Act	N/A	IIT-R							

Table 4. Local actors' contribution to the IIT (part 1 of 2)

ED	D	P	S	I	R	Sub-Domain	ISSUE	sh ws	Domain	Theme
			1			Basin morphology			Basin description	Environmental
			1			Ecosystem functions	Increased habitat range (northward shifts of bird and insect species)	B	Ecosystem /Biodiversity	
							Ecosystem health (soil erosion, soil fertility, soil salinity, water logging, river bank erosion, siltation, sedimentation, sediment load in river)	A, B, S		
			1			Biodiversity	Biodiversity	A, S		
			1			Land use	Land use	B	Land use /	
							Snowfall	S		
			1			Glaciology	Glacier area	B		
			1			Permafrost	Permafrost area	S		
			1			Forest management	Deforestation, forest fires	A, B	Forests	
							Reforestation	A, B		
							Bush encroachment	S		
			1			Water quality	Effluents treatment	A	Water	
							Pollution	A		
		1				Water resources	Ground water level	A		
			1			Water resources state	Water depth	A		
							Natural flushing of wetlands	A		
				1		Water resources impact	Extraction of water	A		
							Impact on aquatic resources			
			1			Water flow	Physical characteristics of the river	A		
							River flow	A, B		
							Runoff	A, B, S		
1						Precipitation	Climate change	A, B, S	Climate	
							Monsoon	B		
							Rainfall, snowfall, extreme events, floods	A, B, S		
				1		Aridity	Drought	A		
			1			Evapotranspiration	Climate change	A, B, S		
1						Temperature	Temperature	A, B, S		
							Climate change	A, B, S		
				1		Vulnerability	Floods, flash floods, GLOFs, landslides	A, B	Environmental hazards	
							Earthquake	A		
							Avalanche control	S		
	1					Poverty	Vicious cycle (poverty-ecology)	A	Livelihoods/ Assets	Social
							Poverty / per capita income	B		
							Lifestyle	A, B, S		
	1					Water availability	Water availability	B		
							Water usage and sectors	B, S		
							Water quality	A, B, S		
							Provision of safe drinking water	A		
	1					Education /Information	Level of education	B		
							Scientific knowledge data availability	B		
	1					Population dynamics	Demographic patterns	A	Population	
							Population growth	B		
							Migration	A, B		
							Displacement of people and communities	A, B		
							Settlement on river banks	A		
	1					Gender issues	Access to resources by women	A, B	Gender	
							Issues of gender: status of women, social and	A		
	1					Age distribution			Community structure	
				1		Morbidity and mortality	Morbidity and mortality caused by floods and climate	A, B	Health/ Sanitation	
							Health status	A		
		1				Sanitation system	Poor infrastructure for sanitation facility	B		
		1				Healthcare delivery	Access to services	A, B		
		1				Housing settlements			Settlements	
		1				Urban settlements	Urban development	A, B		
							Change in settlement patterns	B		
		1				Access to infrastructure			Infrastructure	
	1					Road infrastructure	Road construction and amelioration	A, B		
	1					Water infrastructure	River transport facility	A		
							Drainage facilities	A		
		1				Infrastructure pressures	Damages to infrastructure	B		
							Induced seismic activities	A		
							Dam breakage	A		
							Dam water release	A		
							Impact of infrastructure development	A		
		1				Waste management	Waste disposal	A, B	Wastes	Economic
		1				Energy consumption	Energy use/per capita consumption	A, B	Energy	
		1				Energy production	Hydroelectric plants	A		
							Multi-purpose dams (mini dams)	A		
		1				Agricultural production	Irrigation infrastructure	A	Economic development	
							Land use change in agriculture, agriculture pressures	A, B, S		
							Cropping patterns	B		
							Traditional agriculture	A, B		
							Fisheries	A		
	1					Service sector				
		1				Construction sector	Increase of impervious areas and development of land	B		
							Increased quarrying activities	A, B		
	1					Industrial production	Industrial development	A, B		
	1					GDP/GNP				
	1					Employment	Economic alternatives	A, B		
							Transient labour force	B		
							Child labour	A		

Table 5. Local actors' contribution to the IIT (part 2 of 2)

ED	D	P	S	I	R	Sub-Domain	sh ws	RESPONSE STRATEGIES	category of RS	Domain	Theme
					1	Capacity building	B,S	Develop capacity building and awareness plans for local communities and their leaders	Knowledge improvement and capacity building	Education	Governance
							A,B,S,UB	Increase awareness of the population on risks, conservation and WRM			
							UB	Training of employees and administrative people			
							UB	Strengthen traditional knowledge			
							A, B	Reduce poverty	Governance		
					1	Increase knowledge	A	Integration and coordination among different sectors of research and decision making	Knowledge improvement and capacity building		
							B,S,UB	Increase knowledge on best practices and research on impacts of natural hazards			
							UB	Environmental monitoring			
							UB	Flood modelling			
							UB	Dissemination of knowledge			
							UB	Educational policy	Governance		
					1	Decision making	UB	Inclusiveness and empowerment in the decision making process	Governance	Institutional and legislative frameworks	
							A	Integration of research in decision making			
					1	Public Participation	A,B,S,UB	Improve Community involvement and foster participatory processes for decision making	Governance		
							A,B	Foster livelihood practices based on conservation, rehabilitation and sustainability			
					1	Disaster preparedness	UB	Introduce adequate construction methods	Engineering solutions and land management		
							A,B,S,UB	Early warning systems (EWS)			
							UB	Design policy for flood management	Governance		
							UB	Introduce flood insurance			
							A,B,UB	Disaster risk management	Planning		
							A,S	Protection of communities			
							S,UB	Hazard zonation			
					1	IWRM /NRM	A,S,UB	River training works	Engineering solutions and land management		
							A	Multi-purpose dam construction			
							UB	Control of GLOFs			
							UB	Channel improvement			
							UB	Agricultural practices			
							A,B	Soil conservation efforts			
							A,B,L,UB	Forest management			
							B,L,S,UB	Flood and erosion control			
							L,UB	Reservoirs			
							L,S,UB	Renaturation			
							B,L,S,UB	Watershed management			
							A	Environmental Impact Assessment for new dams	Governance		
							S	Interaction among science, governance and public			
							A,B,L,S	Design and implement IWRM plans	Planning		
							A	Design and implement relief and rehabilitation plans			
							B,S,UB	Land use planning			
							B,S	Retention areas planning			
							B,S	Town planning			
					1	General institutional and legislative frameworks	A,B,S	Accountability and transparency in government actions	Governance		
							A,B,S,UB	Implement and enforce existing laws and design new and more effective laws			
							A,B	Establishment of institutions			
							A,B,L,S,UB	Resolve conflicts and strengthen coordination among institutions			
							UB	Avoid government crisis			
					1	Transboundary issues	A,UB	Inter-state coordination and conflict resolution, cross-boundary issues	Governance	International relations	

3. CHAPTER 3 ANALYSIS OF THE EFFECTIVENESS OF RESPONSE STRATEGIES TO DEAL WITH FLOOD RISK UNDER THE IMPACTS OF CLIMATE CHANGE[16]

3.1. Introduction

This chapter illustrates some of the methods and findings of the BRAHMATWINN Project, with a specific focus on the approach developed for demonstrating the potentials of innovative decision support processes and tools. They are presented for their potential as a methodological and operational reference for the management of decision processes in a participatory context for the development of IWRM plans, including climate change perspectives and adaptation needs.

In this chapter we present a proposal for the management of decision processes in a participatory context for the development of IWRM responses, considering the climate change perspectives and adaptation needs too. In particular some of the methods and findings of the BRAHMATWINN Project are illustrated, by referring to the participatory process carried out in the two river basins in Europe and Asia: UDRB and UBRB. **Paragraph 3.2** describes the methodological framework adopted for the case studies, the information base and the DSS design. **Paragraph 3.3** presents the results of the application of the proposed approach to the BRAHMATWINN project. **Paragraph 3.4** discusses the outcomes achieved and some conclusive remarks are drawn.

3.2. Methods

3.2.1. The methodological framework

The approach adopted for the analysis of alternative adaptation responses is developed upon the NetSyMoD[17] methodological framework (Giupponi et al., 2008) for the management of participatory modelling and decision processes in the field of environmental management, briefly described in **Paragraph 1.1.3.**

NetSyMoD is organised in six main phases. The first three (*Actors' Analysis, Problem Analysis, Creative System Modelling*) were implemented in the initial activities of the project and are not described here. They provided the BRAHMATWINN research with (a) a list of the LAs to be involved in the participatory activities; (b) an in-depth analysis of general problems related to water resources management in the two upper river basins, with the participation of the communities of parties interested in the case study areas; (c) mental model representations of the problems, i.e. qualitative descriptions of the causal links among the various components of the local socio-ecosystems by means of cognitive maps clustered in order to be consistent with the DPSIR framework (EEA, 1999); and (d) extensive data sets deriving from hard science modelling activities, consisting mainly in spatial and temporal data sets describing climate change scenarios and their expected consequences in the study areas.

This NetSyMoD methodology relies on the DPSIR framework, as a comprehensive and simplified conceptual framework for the formalisation of human-environment problems. An extended version of DPSIR is adopted to overcome some of its recognised weaknesses, responding to the necessity, remarked by Svarstad et al. (2008) of expanding the DPSIR framework to incorporate social and economic concerns. In the proposed approach ED are added, to consider all those driving forces that act as external forcing variables to the system representing the study case: for example climate change, or international markets or policies, which are beyond the sphere of the potential effects of the decisions in question. The extended DPSIR framework is used as a communication interface, categorising the various components of the projects (in particular multiple kinds of information and

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Parts of this article have been used to integrate **Chapter 1**

my contribution: definition of the framework for the evaluation of the responses, management of the case study, organization and facilitation of workshops, parts of discussion and conclusions.

[17] NetSyMoD (www.netsymod.eu/) stands for Network analysis, Creative system modelling and Decision support.

knowledge) and facilitating the identification of the main causal relationships, thus framing the need for data processing procedures and modelling capabilities.

The fourth and fifth phases, *DSS Design* and *Analysis of Options*, are aimed at involving the actors and disciplinary experts in the design and evaluation of a set of alternative responses, in this case four broad categories of flood risk mitigation strategies, and are those reported in this chapter. The last phase, *Actions and Monitoring*, is beyond the scope of the research project and it refers to the implementation of the decision taken by the competent administrations.

In particular, the *DSS Design* phase develops upon the conceptual models provided by the previous *CSM* phase and consists of specifications in terms of elaboration and management procedures at the interface between the scientific outcomes of the project and the preferences and expectations of LAs. The *Analysis of Options* implements the results of those elaborations and consists in a series of participatory events supported by an *ad hoc* DSS software: mDSS (Giupponi, 2007). The mDSS tool provides the framework for decision analysis at the interface between scientific outcomes and the preferences of the involved actors, with a set of techniques aiming at the elicitation and aggregation of decision preferences and through the implementation of MCDA (Figueira et al., 2005). MCDA techniques are adopted to assist a decision maker, or a group of decision makers, in identifying the preferred alternative out of a range of alternatives in an environment of diverging and competing criteria and interests (Belton and Stewart, 2002).

In order to implement those two phases, the participation of LAs in the two case studies was achieved through a series of workshops, in which brainstorming techniques were initially used to elicit the most relevant local issues and the most promising responses - potential or in place - to cope with flood risk in a climate change perspective. In parallel, disciplinary experts of the project were involved in an exercise to develop a catalogue of indicators, categorising the widest collection of data provided through analyses and modelling of various kinds and facilitating the communication of the expected outcomes in advance to the interested parties. Local issues raised by the involved actors express the demand of knowledge, while the delivery of information planned by the researchers represents the planned supply of knowledge. The two should in theory match to allow for an effective transfer of knowledge and local impact of the project. This aspect is unfortunately, quite often either neglected in many international research efforts, or considered only in the final phases of the activities, thus dramatically limiting the potential research outcomes. An innovative solution designed to cope with this problem was the implementation of a series of activities carried out in parallel with both the researchers and the LAs belonging to the two case study areas, culminating with the delivery of an extensive IIT.

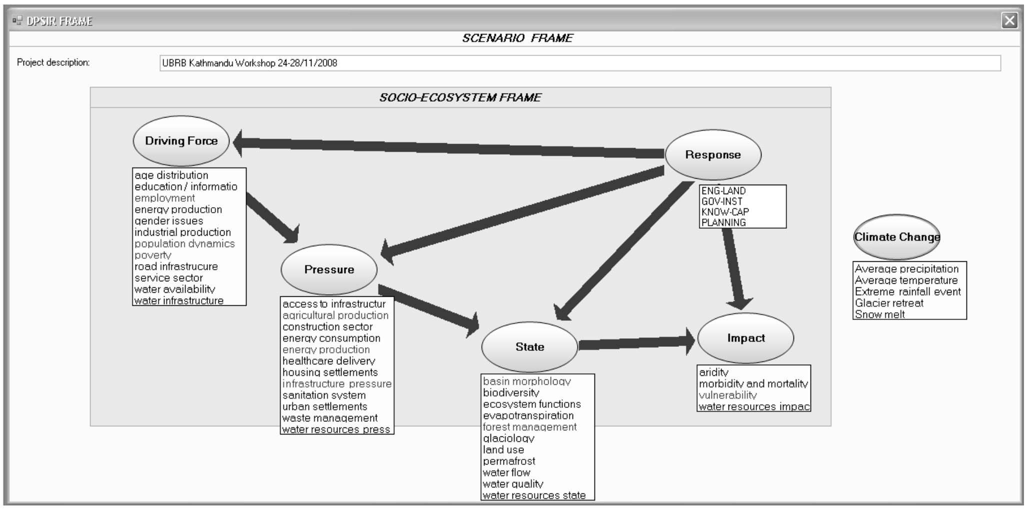


Figure 3. The conceptualisation of the information base stored in the IIT within the extended DPSIR framework (screenshot of the mDSS software).

The IIT represented the main interface to the knowledge base developed by the BRAHMATWINN Project allowing the combination and comparison of the supply and demand of information (see Table 1 for the IIT structure and functions and Table 2 to Table 5 for details). A hierarchical classification of the information relevant to the whole research project is reported, starting with the level of greatest aggregation, i.e. the four "Themes" (Environment, Economy, Society and Governance). The "Themes" are sub-divided into "Domains", which are further segmented into "Sub-domains". Such a categorisation of relevant information for the project was developed in a series of iterations, in which all the project partners were involved. At the highest level of detail "Indicators" were identified by partners (one or more per Sub-domain) as the means of providing a quantitative assessment of the various typologies of information dealt with by the project. The left hand side of the IIT thus represents a comprehensive catalogue of the information provided in the project and intended to be useful for supporting the identification of response strategies at local level (Table 2 and **Table 3**).

On the right hand side of the IIT (Table 4 and Table 5), the issues identified by LAs during the workshops dedicated to the NetSyMoD phases of *Problem Analysis* and *CSM* are assigned to related "Sub-domains", thus providing an interface between the potential supply of information from project activities, and the demand from potential beneficiaries. In general it was possible to create such correspondence, but in some cases it appeared that either the consortium was ready to provide information not immediately relevant to local issues or the LAs were raising issues not dealt with by the project, thus identifying the existence of knowledge gaps.

As described below information categorised within the IIT was at the basis of the organisation of workshops aimed at analysing the expectations and the preferences of LAs in terms of future strategies, to orient the final steps of analysis of the project, with the help of the mDSS software. Therefore, Sub-domains were also assigned to the five nodes of the DPSIR framework, for maintaining the coherence with such conceptual framework and preparing for the utilisation of the mDSS tool (see Figure 3).

In collaboration with project partners the possible IWRM strategies to cope with flood risks in future climate change scenarios in the two areas were divided into four broad categories of Responses (according to the DPSIR definition), in order to involve LAs in the process of targeting and finalising the remaining project activities, as reported in Table 6.

1. ENG-LAND: Engineering Solutions and Land Management (e.g. dam construction, river network maintenance, soil conservation practices, etc.);
2. GOV-INST: Investments in Governance and Institutional Strength (e.g. accountability and transparency in government actions, enforcement of existing regulations, flood insurance, etc.);
3. KNOW-CAP: Knowledge Improvement and Capacity Building (e.g. awareness-raising activities, dissemination of scientific knowledge, training of public employees, etc.);
4. PLANNING: Solution based on planning instruments (e.g. design and implementation of relief and rehabilitation plans, hazard zoning, etc.).

Table 6. Synthesis of Responses elicited in Assam State (India), Wang Chu RB (Bhutan), Salzach RB (Austria), Upper Brahmaputra RB (Kathmandu, Nepal) (in four parts)

Legend of workshop	**A:** Assam	**S:** Salzach river basin
	B: Bhutan (Wang Chu river basin)	**UB:** Upper Brahmaputra river basin

RESPONSES BASED ON ENGINEERING SOLUTIONS AND LAND MANAGEMENT		
SH	SUB-CATEGORIES	ACTIONS
A, S UB	**1. River training works**	• Embankments to be developed in cities where linear measurement are necessary • Construction of levees and of embankments
A	**2. Multi-purpose dam construction**	
UB	**3. Control of GLOFs**	• Lowering of glacier lake water level
UB	**4. Channel improvement**	• Dredging of river bed • River channel management • Desiltation • Deepening and widening of river bed
UB	**5. Agricultural practices**	• Shifting cultivation • Intensification • Control of grazing • Minimum tillage • Change in cultivation patterns

UB	**6. Introduce adequate construction methods**	• Raised platforms • Control quality of constructions • Construct building so they withstand flood
A, B	**7. Soil conservation efforts**	
A, B UB	**8. Forest management**	• Reforestation around built areas with green belt • Afforestation
A, B S, UB	**9. Early warning systems (EWS)**	• Standard EWS in WCRB would help responses at local level • Improve precipitation networks in high alpine areas • Improve precipitation forecast models • Flood forecast
B, S UB	**10. Flood and erosion control**	• Excavation of river beds before the power station • Enable continuous flow and transport of sediments • Check dams
UB	**11. Reservoirs**	• Build dams for retention to control floods • Natural ponds
S UB	**12. Renaturation**	• Reconnection of old cut off meanders • Restoration and renovation of wetlands • Reconnection of retention areas to river
B S UB	**13. Watershed management**	• Integrate land management in the catchment areas across agencies and states • Land management practices to reduce runoff, e.g. build terraces • Strategic level response: mainstream sustainable land management practices into NRM policy guidelines • Agroforestry

RESPONSES BASED ON GOVERNANCE		
SH	SUB-CATEGORIES	ACTIONS
A, B S	**14. Accountability and transparency in government actions**	• Long term strategy for distributing funds • Transparency about where money is spent
A UB	**15. Inter-state coordination and conflict resolution, cross-boundary issues**	• Diplomatic level • Action in upstream affect downstream
A, B S, UB	**16. Implement and enforce existing laws and design new and more effective laws**	• Updating of relief code • Enforcement of existing ground water policy • Need for implementable policies • Incentives for personnel working in risk areas • Strong implementation of laws • Promote awareness of existing initiatives and of present policies • Investigate causes for lack of implementation • Improve effectiveness
A	**17. Environmental Impact Assessment for new dams**	• Dam break analysis
A B S UB	**18. Improve Community involvement and foster participatory processes for decision making**	• Enable participatory approach in monitoring and in decision making • Local conflicts and protection • Involvement of local people in construction • Monitoring of current participation and group decision making • Integrate local mitigation approaches • Scaling up • Facilitate forums to bring stakeholders together • Restoring of local knowledge • Taking indigenous knowledge into consideration • Participatory form of government • Improve women's participation • Introduce community management practices
UB	**19. Inclusiveness and empowerment in the decision making process**	• In planning and implementing
A B	**20. Foster livelihood practices based on conservation, rehabilitation and sustainability**	• Synergy of social and technical response • Relapse to preconditions • Rehabilitation and health issues • More focused rehabilitation policy

		• Sustainable livelihood approach
S	**21. Interaction among science, governance and public**	
A B	**22. Establishment of institutions**	• Central state and district disaster management authorities • North East Water Resource Authority (NEWRA) • GOI Monitoring Committee for proper implementation of World Bank plan • Establishment of the Natural Resource Committee • Local Dev Committee have role to manage NR at that level • National Environmental Protection Act (June 07) - coordination and mandates to National Environment Committee
A, B S, UB	**23. Resolve conflicts and strengthen coordination among institutions**	• Training
UB	**Design policy for flood management**	
UB	**24. Introduce flood insurance**	• Make flood insurance mandatory • Link insurance to zone
UB	**Educational policy**	• Primary school classes on climate change • RSPN and MoE working on curricula for watershed management in schools
UB	**Avoid government crisis**	
A, B	**25. Reduce poverty**	• Poverty alleviation as focus for 10 year plan • Employment generation
A	**26. Integration of research in decision making**	
A, S	**27. Protection of communities**	

RESPONSES BASED ON KNOWLEDGE IMPROVEMENT AND CAPACITY BUILDING		
SH	SUB-CATEGORIES	ACTIONS
A	**28. Integration and coordination among different sectors of research and decision making**	• Dissemination and implementation of inputs • Understanding of consequences • Integrate sectoral programs • Micro-level studies • Coordination of research and policy • Coping strategies → adaptation • Think tank for binding recommendations • Social audit of water use • Implications for health • Regional water policies for local project implementation • Networking among departments • Clear sectoral roles and policies
B S UB	**29. Increase knowledge on best practices and research on impacts of natural hazards**	• International "best practices" (e.g. JP) • Further development of hydrologic studies and models • Carry out research on river basins related to land management • Consider behaviour of small tributaries of rivers
UB	**30. Environmental monitoring**	• Coordination of research work • Need for monitoring • Baseline surveys • Need for historical studies • Data collection • Meteo data • More studies on foothills area and impacts of GLOFs • Increase density of gauging stations
UB	**31. Flood modelling**	• Disseminate
B S	**32. Develop capacity building and awareness plans for local communities and their leaders**	• Capacity building of community leaders • Simulation of potential economic damages caused by flood
A B S UB	**33. Increase awareness of the population on risks, conservation and WRM**	• Increase awareness of communities of risk by maps • Education of communities in NRM • Increased awareness at all levels of the importance of conservation • Increase awareness of communities at risk, to improve coordination and responsiveness of communities

		• Increase awareness of risk by maps
UB	**34. Training of employees and administrative people**	• Administrative, technical, accountable • Refresher course • Intensive training in flood forecasting
UB	**35. Dissemination of knowledge**	• Development of audio-visuals • Disseminate information on flood forecasting • Train people who are living in flood prone areas • Information to people that live in flood risk areas
UB	**36. Strengthen traditional knowledge**	• Identify and promote

RESPONSES BASED ON PLANNING		
SH	SUB-CATEGORIES	ACTIONS
A, B S	**37. Design and implement IWRM plans**	• Need for master plan • Need for common government platform in basin • Strategy and planned actions would contribute to watershed conservation
A	**38. Design and implement relief and rehabilitation plans**	• Relief and resettlement plan • Habitat structuring
A B UB	**39. Disaster risk management**	• Need for a more responsive government • Timely intervention • Localised strategies • National Disaster Risk Management Framework (defines roles and responsibilities) • Capacity development key response strategy • District disaster management guidelines are being prepared (NDRMFW) • National Disaster Management Act and Plan are being formulated • Flood preparedness and fighting
B S UB	**40. Land use planning**	• Evaluate existing land use plans • Protected areas establishment along/in rivers (buffer zones, protected areas) • Catchment area development plan • Unplanned development in flood plain • Coordinate/strengthen regional and community level of planning
S UB	**41. Hazard zonation**	• Flood plain zoning • Evaluate and harmonize existing hazard plans • Restrict construction in risk areas • Historical records of hydrological events • Flood risk mapping • Vulnerability mapping
B, S	**42. Retention areas planning**	• Avoid urbanisation processes in retention areas
B, S	**43. Town planning**	• Bhutan National Urbanisation strategy: classifies types of town, land use,...

3.2.2. The DSS Design and Analysis of Options

Building upon the information acquired in the participatory activities carried out in the first two years of the project and referred to in the first three NetSyMoD phases, two workshops were organised, one in Salzburg, Austria (Danube) and one in Kathmandu, Nepal (Brahmaputra), with the aim of testing the proposed methodology. In order to guarantee the comparability of the results of the two river basins, both workshops were structured using the same procedure, designed with the purpose of building a common language and understanding of the problems within the groups of LAs, and between them and the research consortium. The workshops were organised in two half-day phases (afternoon of day 1 and morning of day 2) and their outline is briefly described below.

The workshops started with the **presentation** of the goals and of the preliminary results of the downscaling of climate change scenarios, by means of storylines developed by the project climatologists (Institute for Atmospheric and Environmental Sciences of Johann-Wolfgang Goethe

University, Germany), focusing on the possible effects of climate change on local water resources over the coming 40 years[18].

Having introduced the problem and the scenarios, a **brainstorming** session was conducted to elicit and consolidate the sets of possible responses within the four main categories that had been defined during the previous project meetings (see Table 6). This section created the basis for the correct implementation of the ensuing steps, and led to the identification of sub-categories and specific actions, within the proposed four major categories of responses.

Having consolidated the identification of responses, participants were asked to select the **criteria** for the evaluation of responses, from the Sub-domains listed in the IIT. Each participant was asked to rank the three most important, within three separate lists for the Economic, Social and Environmental Domains, in terms of relevance for evaluating the responses (40 criteria in total were listed in the IIT).

Once identified the nine most important evaluation criteria (three per each sustainability theme considered), participants were asked to provide **weights** expressing their relative relevance. The criteria-weighting procedure was based on the method proposed by Simos (1990) and revised by Figueira and Roy (2002), which involves the aid of sets of cards. This method was very appropriate for these workshops, because it supports the planned application of the Electre III method (Belton and Stewart, 2002) and because it provided a simple and effective approach for weighting, without the need of a computer lab, which was not always available.

Criteria and responses defined the entries of the **Analysis Matrix** (AM) (9 rows and 4 columns for criteria and response categories, respectively) and, together with the weight vectors, they were used for the subsequent evaluation exercise, by means of the MCDA methods provided by the mDSS software. Participants were asked to fill in the matrix, responding to the question "What is the potential effectiveness of the responses (columns) in coping with the issues expressed by the criteria (rows)?" In practice, they evaluated the potential effectiveness of each response (columns) in coping with the issues expressed by the criteria (rows) by means of a Likert scale (from 1 to 5 ranging from "very high expected effectiveness" to "very low expected effectiveness").

A second Likert scale was added in every cell to analyse the degree of confidence and **uncertainty** related to LAs opinion (IPCC, 2005), i.e. a rough idea about the uncertainty related to the judgement provided for every combination of response category and assessment criterion. In the forms distributed to workshop participants, the concept of uncertainty was specifically related here to their perceptions of the limits in the predictability of the effectiveness of the responses.

The compilation of the AM concluded the first part of the NetSyMoD workshop. All the data collected were coded with a spreadsheet software and then passed to the mDSS tool, for Multi-Criteria Analysis (MCA) and Group Decision-Making (GDM). The mDSS software allowed for the comparison of the alternative options using MCA techniques, by operating parallel evaluation processes, representing the preferences of each participant. In practice, the qualitative evaluations contained in the AM were transformed into normalized scores that expressed the performances of the responses in real numbers ranging between 0 and 1, and subsequently processed by means of the ELECTRE III **decision rule** (Belton and Stewart, 2002), allowing the aggregation of partial preferences describing individual criteria into a global preference and the ranking of the alternative strategy categories. ELECTRE adopts a pairwise comparison of the alternatives, so it is computationally rather demanding, but very simple to be applied by practitioners. The preference (P) and indifference thresholds (Q) were parameters defined by the research team as an input, while no veto threshold (T) was introduced in the analysis, because not pertinent to the selected indicators and analytical context.

Results of individual outranking procedures were subsequently combined in a **Group Decision-Making** procedure by means of the Borda rule (de Borda, 1953).

All the results of the data processing were reported to the participants in a final plenary session of the NetSyMoD workshop.

3.3. Results

The two workshops in the Danube and Brahmaputra were conducted in parallel without exchanges of information between the two communities of LAs. Even so, five out of nine selected criteria are common to the two cases revealing that in the two river basins, though characterised by different

[18] Climate Change scenarios provided climate simulations using three IPCC-SRES scenarios (A1B, A2 and B1; IPCC, 2000) and the COMMIT scenario (i.e. the consequence of committing world economies to limit GHG concentrations at 2000 levels), five data sets (GPCC, UDEL, CRU, EAD, F&S) and four models (ERA40, CLM-ERA40, ECHAM5, ECHAM5-Γ).

geographical locations, ecological, social and economic dimensions, LAs approach decisions about future strategies in a similar way, i.e. by basing the decision upon a similar set of criteria.

A valuable outcome of the twinning approach, therefore, has been the delineation of some crucial aspects related to flood risk and CCA strategies in the two river basins. Vulnerability was one of the highest weighted criteria, demonstrating the relevance of the issue and, in general, the concern on the two basins' ability to cope with the adverse effects of climate change in the future. Vulnerability is a hotly debated concept, but according to the IPCC (2007b), vulnerability is determined by the exposure to climate change, by the physical setting and sensitivity of the impacted system, and by its ability to adapt to change. Following this definition, an interpretation of LAs' opinions expressed during the workshops can be provided.

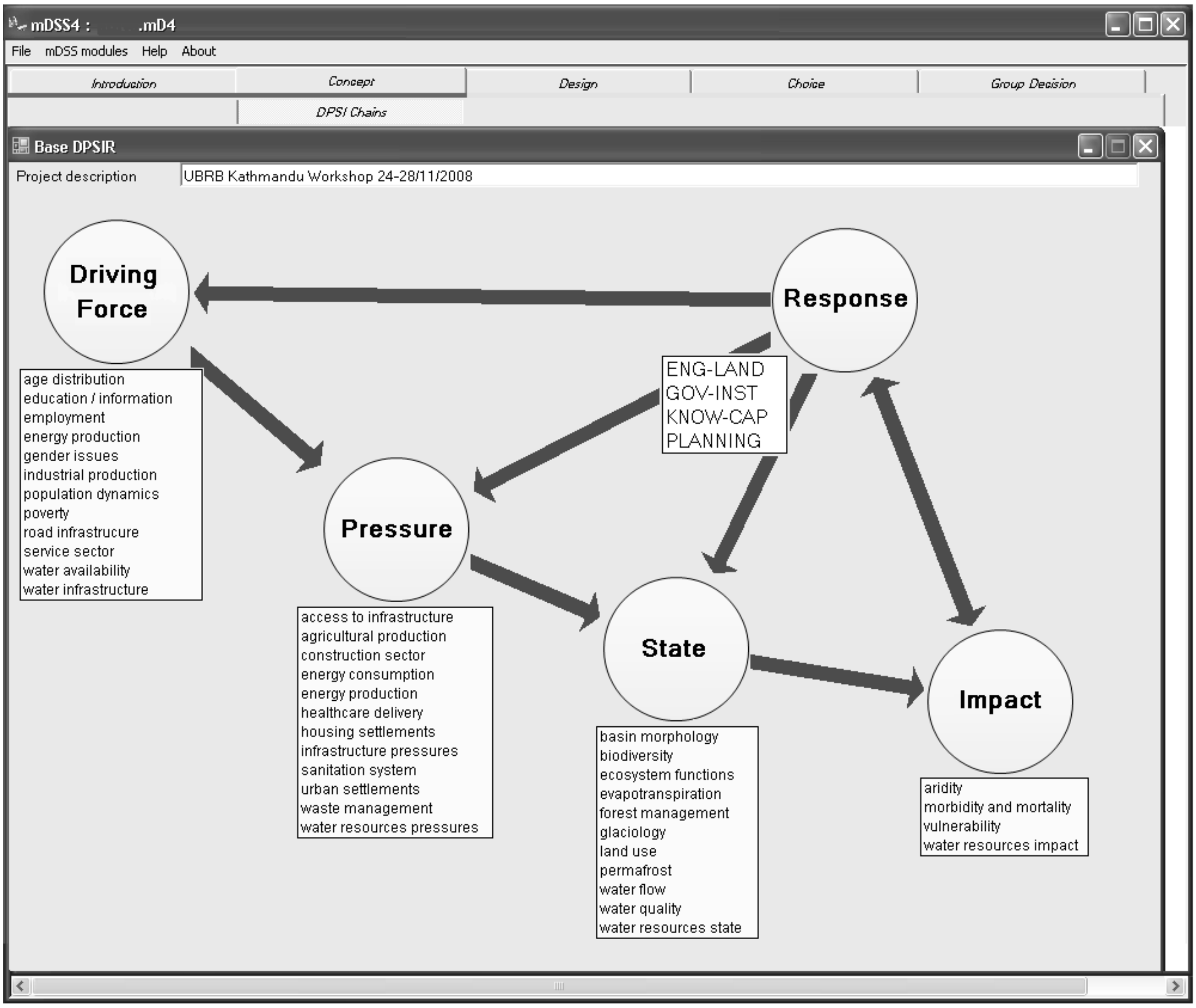


Figure 4. The conceptualisation of the information base stored in the IIT within the DPSIR framework (screenshot of the mDSS software).

The exposure to climate change risks is clearly related to *Basin Morphology*, that is the physical characteristics of the drainage area, which could appear an obvious consideration, but, on the contrary, it highlights here that the design of actions and strategies lacks careful consideration of the specificity of the area. *Population Dynamics* is contemplated as one of the most important driving forces to be studied to cope with flood risk. Population size and growth, the distribution across urban and rural areas, population concentration, the distance between settlements and riverbanks, are examples of some of the aspects to be evaluated in the strategy design. Also the role of *Agriculture Production* has to be carefully considered by policy makers. Critical issues are related to irrigation infrastructure and extension, ratio of commercial agricultural land per household, household agriculture dependence as a primary source and cropping patterns and diversity. Finally, the pressure caused on *Infrastructure*, according to the LAs, has to become one of the central points of flood risk reduction strategies. Attention has to be paid to the extent of potential damages caused by floods to human infrastructures, like dams and reservoirs; aspects like the probability of dam break, the reservoir-induced seismicity, the downstream stream bed retrogression, the upstream reservoir sedimentation volume and submergence area have to be studied and integrated in the policy focus.

Besides the emergence of such similarities, the exercise of criteria selection also evidenced the significantly different relevance attributed to a series of proposed criteria out of the lists of proposed Sub-domains. In the Brahmaputra, to which mainly low-income countries belong, "*Poverty*" was picked as the most relevant criterion, highlighting how the poverty level and low life standards strongly affect the significance of flooding damages in the area.

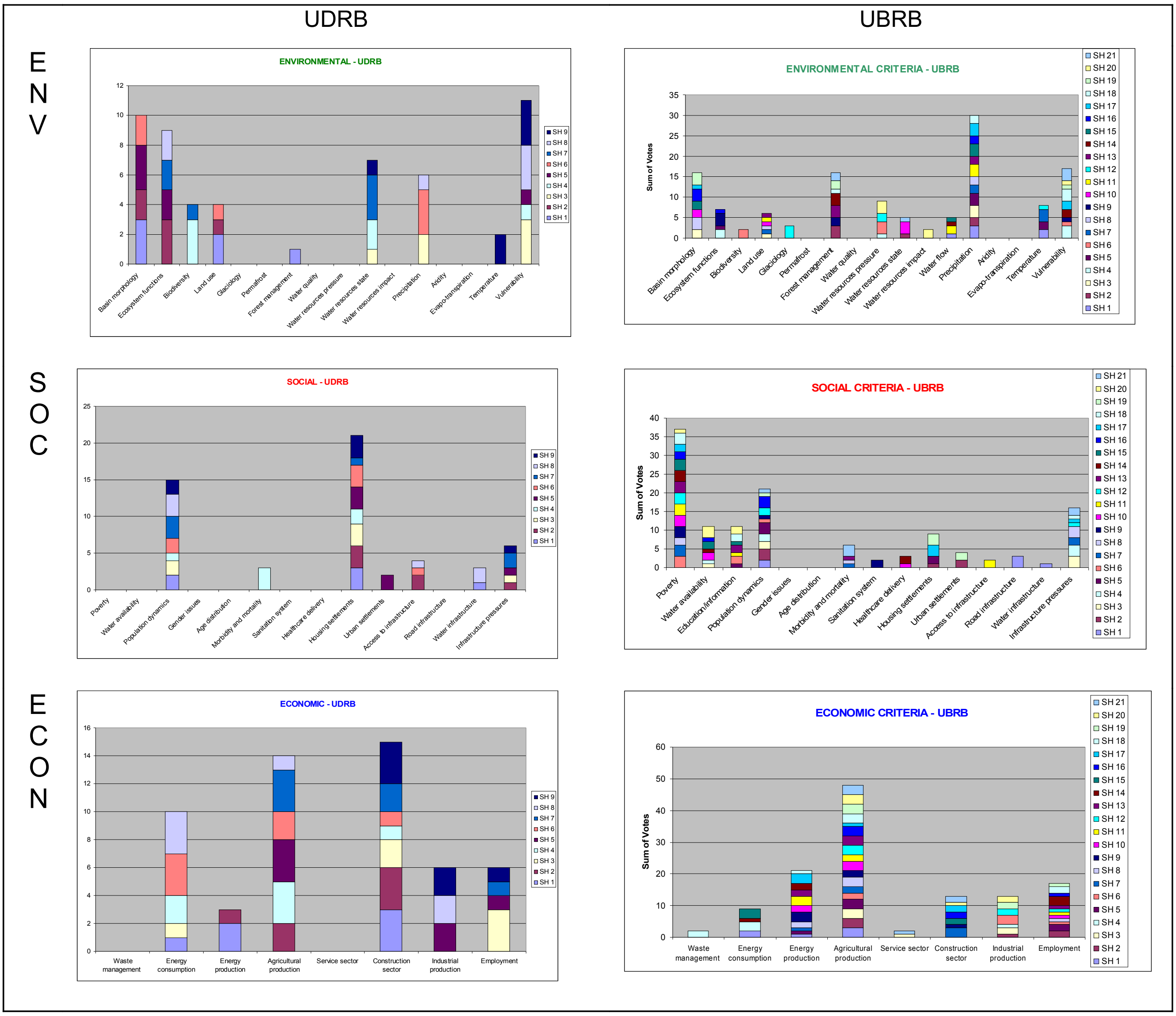


Figure 5. Votes attributed to Environmental, to Social, and to Economic sub-domains for the UDRB (left column) UBRB (right column).

It is, indeed, recognized that poverty is directly related to vulnerability to climate change, since it is a determinant of adaptive capacity. Countries with limited economic resources are likely to have also poor infrastructure, fragile institutions, low levels of technology, reduced skills, limited access to information and to resources, and consequently little capacity to adapt. Poverty is both an important determinant of endogenous environmental risk, and hence indirectly of socioeconomic vulnerability, and an important constraint of adaptive capacity (Brouwer et al. 2007). Hence, poverty reduction policies would indirectly reduce the exposure to flood risk. It is also interesting to notice that *"Forest management*" was selected in the top-3 environmental Sub-domains only in the Brahmaputra. In the Danube, instead, LAs concentrated their votes on "*Housing settlements*", showing a different perspective in the European area when considering flood risk. According to LAs, the flood risk in the Danube seems to be affected mostly by housing concentration, high population density and the concentration of residential constructions in areas exposed to flood risk. With respect to the economic criteria, "*Agriculture production*" was considered as one of the most relevant in both river basins. This confirms that, according to the LAs' opinion, agricultural systems, irrigation infrastructures and land use in general are crucial and can contribute to either aggravate or reduce the risk of flooding.

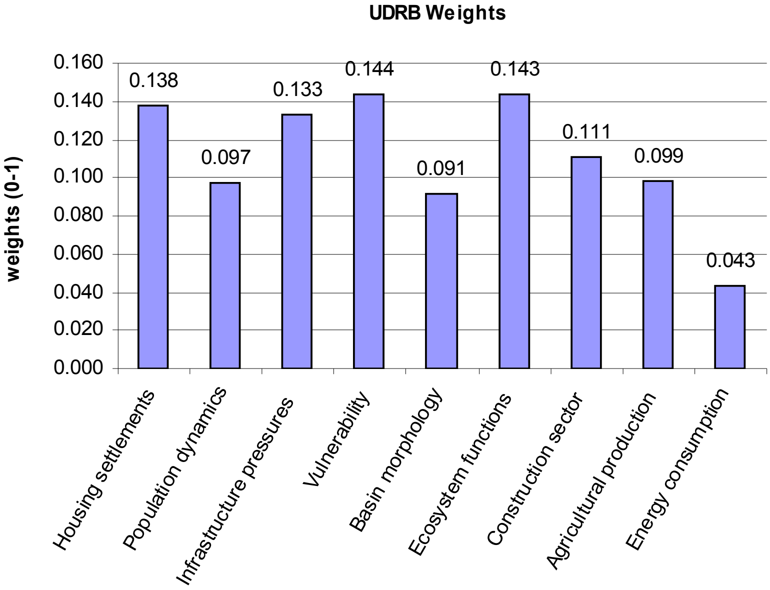
Having identified the set of nine evaluation criteria, workshop participants then defined their relative importance by attributing criteria weights (Figure 6 & Figure 7), providing information about the relative relevance to be given to the criteria in the final ranking of alternatives. Besides the difference in the relative importance of each criterion, it is interesting to observe that in both river basins LAs tend to hold environmental and social criteria in greater regard than economic ones. We can easily see this by summing up criteria weights for each dimension: the environmental dimension was considered the most important, accounting for 38% of the total weights, followed by the social (36-37%) and lastly by the economic one (25-26%).

Table 7. Weights for selected sub-domains (in bold common ones)

UDRB WS criteria selected	weight	UBRB WS criteria selected	weight
Vulnerability ENV	**0.144**	**Vulnerability ENV**	**0.145**
Housing settlements SOC	0.138	Forest management ENV	0.113
Ecosystem functions ENV	0.143	**Population dynamics SOC**	**0.132**
Infrastructure pressures SOC	**0.133**	Poverty SOC	0.125
Agricultural production ECON	**0.111**	**Basin morphology ENV**	**0.125**
Construction sector ECON	0.099	**Agricultural production ECON**	**0.103**
Population dynamics SOC	**0.097**	Energy production ECON	0.101
Basin morphology ENV	**0.091**	**Infrastructure pressures SOC**	**0.100**
Energy consumption ECON	0.043	Employment ECON	0.056

The calculation of weights by means of average aggregation, however, can homogenise and flatten the values. Aggregate values can therefore hide important information, such as divergence and convergence of participants' opinions. The discordance in the weight evaluations clearly reflects the different perceptions and objectives of LAs, and reveals the presence of possible conflicting interests among them. The elicitation of weights is therefore a very crucial phase, because weights can strongly influence the results (Belton and Stewart, 2002). In fact, in theory, an equal representation and integration of all the issues at stake should be guaranteed in participative exercises. In our case, after analysing the distribution and the spread of individual preferences for each criteria weight using Box and Whisker plots (see Figure 7), we were able to verify that in general, among the Danube participants, there was a reasonable concordance in weight attribution, while, on the contrary, among Brahmaputra respondents we observed high discordance in weight evaluations.

This result pointed out the need for a sensitivity analysis, for the Brahmaputra case, to monitor how changes in the weight sets could influence the final ranking. Sensitivity analysis, indeed, is necessary to improve the quality of environmental decisions and verify the robustness of the results (French and Geldermann, 2005; Cloquell-Ballester et al., 2007), and it should, therefore, be recommended in all the cases of implementation of the proposed approach in the practice of decision making. In this exercise the sensitivity analysis of weights was performed by exploring the effects of incrementing and diminishing one weight at a time by 25%, 50% and 75%, and rescaling all the others while maintaining the original proportions amongst them. The sensitivity analysis results are discussed further on in the article.



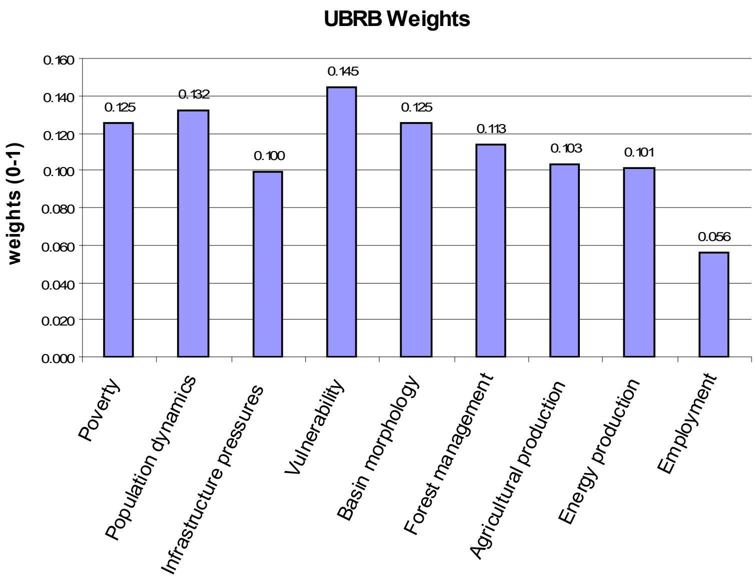
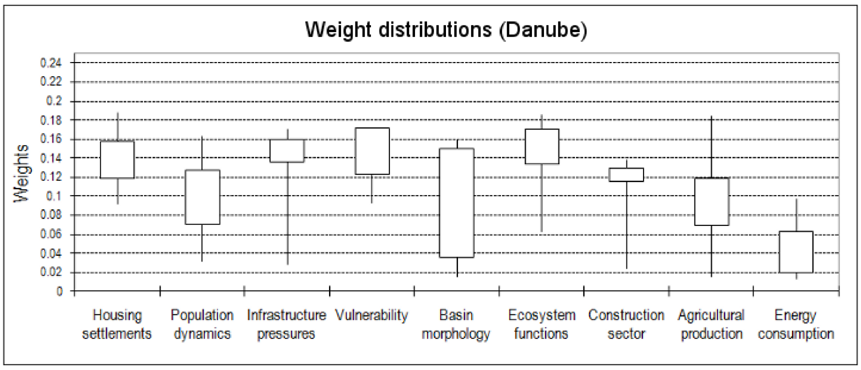


Figure 6. Weights for selected sub-domains

The following step was the elaboration of the AM for each river basin, aggregating and averaging the information collected from each individual AM of participants. Two average AMs resulted (Table 8). From the observation of preliminary data, the results in both the Danube and Brahmaputra showed that none of the categories of strategies clearly dominates the others. All the average criterion scores (bottom rows) or responses (columns farthest to the left) are in a range between "very high effectiveness" and "medium effectiveness", meaning that all the responses are considered to be potentially effective to cope with flood risk and important to deal with the selected environmental, social and economic criteria.

This result is not too surprising. Indeed, throughout the participatory process developed along the entire project, LAs gradually shared their knowledge and perceptions of the various aspects discussed around adaptation strategies to climate change. This process enhanced a shift in LAs views of the problem, from a more individualistic perspective to a common understanding of the interdependence of its multiple dimensions and, thus, of the related policies to cope with. This emphasizes the role of scientists in supplying such a communication platform and confirms the great potential of this methodology to boost knowledge sharing and mutual learning between scholars and LAs.



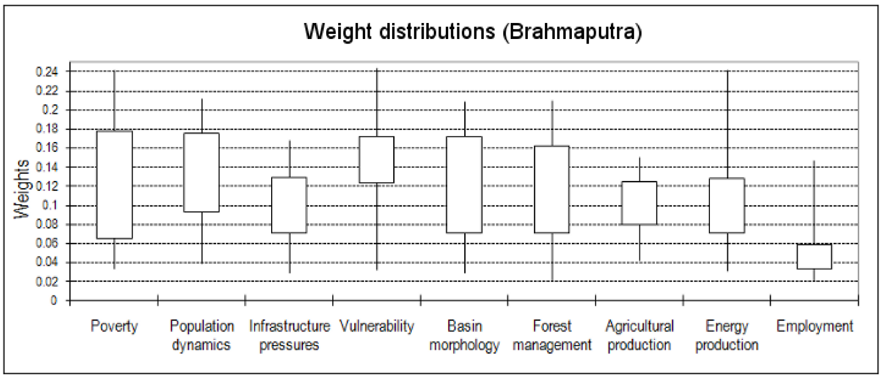


Figure 7. Spreads of weights as expressed by workshop participants in the two river basins . The central box includes the distribution of opinion between the 25th and the 75th percentile (i.e. 50% of the central distribution of opinion); the two whiskers (plus and minus) include the whole range (min-max) of weights' distribution

A supplementary validation of these results is given by the analysis of confidence scores attributed by LAs to their evaluations. The LAs were asked, indeed, to indicate the degree of confidence related to their answer (normalised scale of confidence ranging between 1 "Very high confidence" and 0 "Very low confidence"). All the answers were given with a confidence above the normalised value of 0.5 and very close to the highest one (i.e. 1.0).

The last part of the analysis consisted in calculating the ranking of alternative responses by applying the MCA capabilities of the mDSS software. The partial scores describing the performance of each alternative response with respect to each single criterion were thus aggregated, considering the elicited weights and following the decision rule adopted (i.e ELECTRE III). On average, LAs of both river basins evaluated the PLANNING solution as the most effective one. The remaining categories show different preferences and ranking in the two basins: in the Brahmaputra the second ranked category is ENG-LAND (e.g. dam construction, river network maintenance, soil conservation practices, etc.), there is no preference between investments in GOV-INST (e.g. accountability and transparency in government actions, enforcement of existing regulations, flood insurance, etc.) and KNOW-CAP (e.g. awareness-raising activities, dissemination of scientific knowledge, training of public employees, etc.). The LAs of the Danube instead ranked ENG-LAND as strictly dominated (not preferred) by all the other alternatives, with GOV-INST and KNOW-CAP ranked third and fourth, respectively.

Given the broad meaning of the categories of strategies considered and the exploratory context of the exercise with a relatively high number of stakeholders involved, dramatic differences in the performances were not expected and the differences of the performances were not of great interest. The robustness of the ranking was instead a main issue, because the following steps of the project went into a more detailed analysis of possible strategies within the preferred category identified at this stage.

The robustness of the results was explored and confirmed firstly with a sensitivity analysis of weights, which showed an overall stable performance. In the Brahmaputra basin, all the verified variations of weights (from ± 25%, and ± 50%) did not induce an overturning of the ranking, confirming PLANNING as the preferred option and ENG-LAND as the second ranked category. In the Danube basin the ranking was confirmed with variations of weights by ± 25%, while it was observed that a variation by

+50% of the criterion *Population Dynamics,* or of the criterion *Infrastructure Pressure* by -50% would determine a change of the ranking . These variations are indeed very high, so that the results can still be considered robust enough, nevertheless it should be mentioned that in those cases the GOV-INST became the preferred category, thus pointing out a slightly different perspective of the Danube stakeholders.

Table 8. AM - average values of LAs' evaluations on the potential effectiveness of each response in coping with the issues expressed by the criteria (rows) by means of a Likert scale ranging from 1 "Very high effectiveness" to 5 "Very low effectiveness".

AM (Average values) **Upper Danube RB**		PLANNING	KNOW-CAP	GOV-INST	ENG-LAND	**Average**
SOC.1	Housing settlements	2,00	2,43	2,57	2,71	2,43
SOC.2	Population dynamics	2,86	3,00	2,29	3,29	2,86
SOC.3	Infrastructure pressures	2,43	2,14	2,57	2,00	2,29
ENV.1	Vulnerability	2,33	2,67	2,50	2,67	2,54
ENV.2	Basin morphology	2,71	2,57	3,43	3,29	3,00
ENV.3	Ecosystem functions	2,86	2,43	2,29	3,43	2,75
ECO.1	Construction sector	2,14	3,29	2,57	2,43	2,61
ECO.2	Agricultural production	2,86	3,14	2,71	2,57	2,82
ECO.3	Energy consumption	2,86	2,43	2,57	2,86	2,68
	Average	2,56	2,68	2,61	2,80	

AM (Average values) **Upper Brahmaputra RB**		PLANNING	KNOW-CAP	GOV-INST	ENG-LAND	**Average**
SOC.1	Poverty	2,43	2,62	2,00	3,33	2,60
SOC.2	Population dynamics	1,76	2,52	2,33	3,19	2,45
SOC.3	Infrastructure pressures	2,00	2,86	2,67	2,19	2,43
ENV.1	Vulnerability	1,71	2,43	2,24	1,95	2,08
ENV.2	Basin morphology	2,38	2,67	3,10	2,43	2,64
ENV.3	Forest management	1,86	2,10	2,10	1,95	2,00
ECO.1	Agricultural production	2,15	2,50	2,48	2,29	2,35
ECO.2	Energy production	2,19	3,00	2,43	2,10	2,43
ECO.3	Employment	2,43	2,57	2,43	3,52	2,74
	Average	2,10	2,58	2,42	2,55	

Moreover, in order to explore the possible effects of averaging the preferences of multiple actors in terms of both analysis matrices and weight vectors, the data collected from each LA were also processed separately thus obtaining multiple final rankings of options. All the rankings obtained were subsequently processed in mDSS using the GDM capabilities, by means of the Borda Rule. The Borda rule counts how many times each category of responses is preferred to each of the other options by interviewed LAs, and sums up the so called "votes in favour"[19]. According to Borda mark (Table 9), we observed that the PLANNING category is the dominating solution (most preferred one) in both basins, with 10 votes in the Danube and 38 in the Brahmaputra, respectively.

For the purposes of the exercise within the activities of the BRAHMATWINN Project, the results were robust enough to orient the attention of the researchers toward analysing in greater detail the

[19] The votes in favour, in Borda mark, consider strictly preferences and do not count indifference.

strategies for mitigating flood risks in a climate change perspective within the broad category of PLANNING. Discussions with LAs were useful to better define strategies and actions which should be considered within the preferred category of PLANNING measures, and assessed in a more detailed second round of analysis supported by mDSS (see **Chapter 4**).

In both basins the attention was driven to: improving the implementation of existing land use plans; establishing protected areas along rivers; designing new catchment development plans; coordinating regional and community level planning; evaluating and harmonizing existing hazard plans; restricting the construction in risk areas; realizing flood risk mapping and zoning and vulnerability mapping. In the Danube river basin LAs also pointed out strategies oriented toward designing and implementing IWRM plans, underlining the need for a common government platform of the basin, and strategies focused on the planning of retention areas and urbanisation processes. In the Brahmaputra basin, LAs also focused their attention on strategies related to disaster risk management act and plan, for an earlier intervention and community preparation to flood occurrence.

Figure 8. Responses for ELECTRE. UDRB (top) and UBRB (bottom)

Table 9. Group Decision Making marks. The first number refers to the N. of votes in Favour, while "I" refers to the votes of Indifference.

UDRB	PLANNING	ENG-LAND	KNOW-CAP	GOV-INST	sum of votes in favor	BORDA Mark
PLANNING	---------	3 (I=0)	4 (I=0)	3 (I=2)	**10**	**1°**
ENG-LAND	4 (I=0)	---------	1 (I=0)	2 (I=0)	**7**	**3°**
KNOW-CAP	3 (I=0)	5 (I=1)	---------	1 (I=3)	**9**	**2°**
GOV-INST	2 (I=2)	5 (I=0)	3 (I=3)	---------	**10**	**1°**
UBRB						
PLANNING	---------	10 (I=6)	16 (I=3)	12 (I=5)	**38**	**1°**
ENG-LAND	5 (I=6)	---------	9 (I=4)	8 (I=6)	**22**	**2°**
KNOW-CAP	2 (I=3)	8 (I=4)	---------	8 (I=6)	**18**	**3°**
GOV-INST	4 (I=5)	7 (I=6)	7 (I=6)	---------	**18**	**3°**

3.4. Discussion and conclusions

The NetSyMoD methodological framework developed for the integrated participative activities of the BRAHMATWINN Project, with the involvement of both researchers and LAs, facilitated in general communication and exchanges of experiences between the twinned river basins, and among scientists of different disciplines and LAs, through a continuous interaction and feedback process. In particular, the participative process proposed contributed significantly to ensuring that the scientific knowledge and approaches offered could meet the perceptions and needs of local people and decision makers, who would ultimately be the end-users of the project's outputs. The process also enabled the management of the different roles needed according to French and Geldermann (2005): researchers giving insights on how the future might unfold, with LAs providing judgements on the expected feasibility and effectiveness of the responses to cope with flood risk. In this case adaptation responses to climate change have, therefore, been evaluated by those adapting, i.e. LAs as suggested by de França Doria et al. (2009).

These findings show great potential for addressing further research efforts more effectively. In the case of the BRAHMATWINN Project the results reported herein allowed for more targeted final activities, including a subsequent round of Analysis of the options focused on a set of possible strategies within the broader category of "Planning" approaches.

Looking at LAs' contributions during the brainstorming phase of the workshops, we can interpret the preference given to "Planning" in a general way: there needs to be some kind of response developed a priori, so that when flooding occurs local authorities and communities know how to behave during and after the emergency, e.g. the design of relief and rehabilitation plans and disaster risk management. Also, in a stricter sense, LAs referred to the need of physically identifying and mapping hazard areas, such as flood risk zoning, and, more generally, land-use planning. The emergence of "Planning" as the most promising response in both basins might therefore mean that not only do LAs think that "Planning" is most needed in absolute terms, but also that it is currently the most deficient of the four categories presented. In the Danube, LAs acknowledged that change in land-use planning after major flooding events - even if partial - had been a key factor for the prevention of damage in more recent flood events.

Examples of change are the projects implemented for the renaturation of the river banks, which, according to some LAs, should be extended to other areas. However, LAs have also expressed the need to evaluate, harmonize, and implement existing plans. On the other hand, in the Brahmaputra the importance given to population density and poverty (i.e. second and third most important criteria) is related to the fact that many settlements are found in high risk areas, which are sometimes the only place where poor people can afford to live. The concern for encroachment on Brahmaputra's banks as one of the factors limiting the possibility of risk reduction voiced in the workshop confirms this hypothesis. LAs of the Brahmaputra have expressed the need for land-use planning to deal with concerns for urbanization processes along the river banks, which should be prohibited and people already living there should be resettled.

The results were also circulated within the research consortium to direct the attention of modellers to the subsequent phases of the project, with the idea of providing a quantitative assessment of the strategies within the assessment framework described here. However, the ambition to substitute LAs' expectations elicited through the Likert scale at the workshops, with quantitative assessments provided by models proved to be beyond the capabilities of the project, mainly because of time constraints. It should therefore be recommended that when approaches deriving from the one proposed here are adopted, the work plan be carefully defined with adequate time length and with the possibilities of (re)orienting hard science modelling according to the issues and the expectations elicited from the stakeholders.

Besides the methodological framework, also the mDSS software raised great interest among the participants, who were involved in the project activities since its initial phases, exposed to preliminary results and asked to contribute to orient the final phases of the project. Several participants appreciated the use of public domain software in particular, because it allowed the reuse of the approach proposed in local decision problems. In the scientific literature elements such as the timely involvement of stakeholders and the free availability of tools for reuse in local cases and elsewhere have been quite often proposed, but rarely applied in practice.

In this regard the results of this research are encouraging, because they advance our understanding of adaptation to climate change in river basins, and in particular they demonstrate how strategic planning can be implemented in practice, with the support of freely available tools. Starting with the brainstorming in each workshop we were able to elicit and develop a number of responses, needed or in place, to cope with flood risk and future scenarios. LAs of both basins were able to identify responses based on their knowledge and understanding, but also based on other responses identified in previous workshops, either in the same or in the other basin. This was possible thanks to the fact that besides the two workshops described in this article five others were held, i.e. a total of seven workshops took place according to the sequential and iterative process envisaged by the NetSyMoD framework.

In general, the experimental application of the NetSyMoD approach to the study areas provided a means to concretely carry out the twinning of the two river basins, shedding light on the commonalities and distinct features. This study approach led to structured and very effective discussions concerning adaptation responses to flooding in those areas, and allowed for the collection of a significant amount of insights and lessons, drawn from the involvement of LAs. From the evaluation questionnaires collected at the end of the events, we had no evidence of problems concerning the opportunities to freely and equally express opinions, possible biases, or about the process being guided by a dominant discourse, which may delegitimize some of the stakeholders only because they do not subscribe to a preliminarily defined agenda (Griffin, 2007).

As a final remark it should be remembered that the participatory processes described above were at least to some extent, academic simulations of social processes, since they were carried out within the activities of a research project; this implies that the results must be considered mainly for their role in methodological test and demonstration. For this reason, crucial aspects of real world applications were not dealt with by the project, such as the statistically sound identification of representative LAs. Having clarified this at the outset with the participants involved, these activities provided at least two very important opportunities and one caveat: (1) testing and refining methods and tools to be applied in real world decision processes, and (2) disseminating information about scientific developments and the availability of methods and tools to potential users of the project results. Regarding the caveat, it should be remembered that participatory activities should be carefully planned, designed and managed and that methods and tools are not enough - skilled professionals are needed too. This points to the need for future training efforts specifically targeted to provisioning the participatory processes to be implemented in IWRM and CCA processes with professionals of adequate capabilities.

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4. CHAPTER 4
DESIGN OF RESPONSES BASED ON "PLANNING" TO DEAL WITH FLOOD RISK IN A CHANGING CLIMATE[20]

4.1. Introduction

This chapter is strongly based on outcomes of previous research phases described in BRAHMATWINN deliverables[21], especially Deliverable 6[22] and Deliverable 8[23], which are in turn based on previous deliverables (Deliverable 2[24], Deliverable 3[25], Deliverable 4[26]). We can thus say that with the phase described here we have achieved the in depth definition of Integrated Water Resource Management Strategies options envisaged as a conclusion of Deliverable 8. In Deliverable 8, in fact, we had ended with the outcome of the two workshops carried out with LAs[27] in Salzburg for the UDRB and in Kathmandu for the UBRB, in October and November of 2008 respectively. The LAs that participated in both workshops evaluated responses[28] based on the Planning category as the most promising to cope with flood risk, which should increase because of the impacts of climate change.

LAs that participated in two ad hoc workshops were first presented with scenarios of climate change based on the results of the downscaling of the Global Circulation Model done by the research partners of the University of Frankfurt (JWG) in Deliverable 2; and then requested to evaluate the effectiveness of four categories of responses to cope with flood risk in the climate change scenarios presented. From that analysis of the effectiveness comes the need to better define what IWRM option should be implemented. The categories of responses analysed are, in fact, too broad to be implemented, thus the need for further specification arises.

This chapter is thus the conclusion of a participative process carried out during the BRAHMATWINN project, aimed at identifying pressing issues in the UDRB and in the UBRB, and possible responses to them. This process is the result of the interaction of BRAHMATWINN scientists with LAs. Continuous feedback opportunities have been created during the project years, so that the two communities could share knowledge among and within them.

Climate Change scenarios presented in the workshops provided climate simulations using three IPCC-SRES scenarios (A1B, A2 and B1) and the COMMIT scenario (i.e. the consequence of committing world economies to limit GHG concentrations at 2000 levels), five data sets (GPCC, UDEL, CRU, EAD, F&S) and four models (ERA40, CLM-ERA40, ECHAM5, ECHAM5-Γ).

The four categories of responses presented are: (1) Engineering solutions and land management, (2) Knowledge improvement and capacity building, (3) Governance and institutional strength, (4) Planning. According to the MCA carried out with the help of the mDSS software, Planning was chosen as the preferred response. From that analysis of the effectiveness of responses comes the need to better define what IWRM option should be implemented. The categories of responses analysed are, in fact, too broad to be implemented, thus the need for further specification arises.

This chapter is thus the conclusion of a participative process carried out during the BRAHMATWINN project, aimed at identifying pressing issues in the UDRB and in the UBRB, and possible responses to cope with them. The three rounds of interaction carried out among BRAHMATWINN project partners (described in **Paragraph 2.2**), along with the CSM workshops in which LAs expressed their opinions (described in Deliverable 4 and Deliverable 6), resulted in the creation of the IIT. The IIT enables

[20] This chapter corresponds to Deliverable 10.3 (accessed January 2011) http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_10.pdf
[21] Deliverables of the BRAHMATWINN research project can be found here (accessed January 2011): http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/
[22] http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_6.pdf
[23] http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_8.pdf
[24] http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_2.pdf
[25] http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_3.pdf
[26] http://www.brahmatwinn.uni-jena.de/fileadmin/Geoinformatik/projekte/brahmatwinn/Berichte/Dl_4.pdf
[27] We have preferred to use the term local actor (LA), to identify all the people involved in the case study activities instead of the more commonly used term stakeholder, to emphasise the fact that they were people who did not belong to the project consortium (typically local experts or policy makers), involved in project activities by partners responsible for the management of case studies to provide advice and steer project activities, without the ambition to assess their representativeness with robust procedures, such as Social Network Analysis.
[28] In this context the word response is defined according to the DPSIR framework (EEA, 1999) as strategies to be put in place to cope with environmental issues identified.

measurement of issues by means of an indicator. Moreover the IIT lists possible responses, in relation to the governance framework, to cope with scenarios of climate change. The creation of the IIT is the result of the interaction of BRAHMATWINN scientists with LAs. Continuous feedback opportunities have been created during the project years, so that the two communities could share knowledge among and within them.

4.2. Method

4.2.1. The framework

The approach adopted for the analysis of alternative adaptation responses is based on the NetSyMoD methodological framework (Giupponi et al., 2008; www.netsymod.eu) for the management of participatory modelling and decision processes (Figure 9). This methodology relies on the DPSIR framework (EEA, 1999). The DPSIR framework, although widely used, is the object of some criticism, because it is not believed to be a neutral framework, but rather one which is best suited for biodiversity management leading to "Preservationist discourse" options (Svarstad et al., 2008). Svarstad et al. (2008) conclude that the DPSIR framework should be expanded to incorporate social and economic concerns. In the research presented in this deliverable, we have shown a possible way to achieve this.

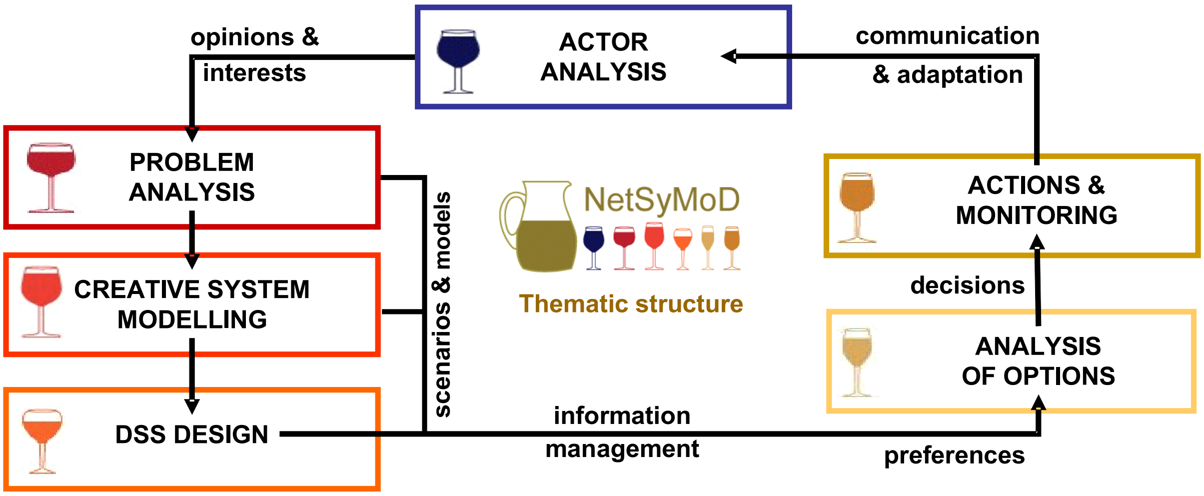


Figure 9. The NetSyMoD flowchart

The NetSyMoD methodology is organised in six main phases. The first three (*Actors' Analysis, Problem Analysis, CSM*) provided the BRAHMATWINN Project with (1) an in depth analysis of general problems related to water resources management in the two upper river basins, with the participation of the communities of interested parties in the case study areas, and (2) mental model representations of the problems, i.e. qualitative descriptions of the causal links between the various components of the local socio-ecosystems by means of cognitive maps clustered in order to be consistent with the DPSIR framework, used as an upper – aggregated – level communication interface. The subsequent phases, *DSS Design* and *Analysis of Options* contributed in **Chapter 3** to the design and evaluation of a set of alternative categories of responses (Engineering solutions and land management, Knowledge improvement and capacity building, Governance and institutional strength, Planning) obtained with group elicitation techniques and with the application of the DSS tool. The result of this iteration of the *DSS Design* and *Analysis of Options* was that the Planning category, evaluated as the most effective to cope with flood risk under the impact of the scenarios of climate change, needed to be analysed and defined in a more specific way.

This second *DSS Design* phase, object of this deliverable, consists of a brainstorming, aimed at a more in depth specification and definition of what is meant for responses based on Planning. The *Analysis of Options* is also again performed with the mDSS software through MCDA, which provides a framework for decision analysis, and with a set of techniques aiming at the elicitation and aggregation of decision preferences (Figueira et al., 2005). In this case, MCDA demonstrates how to assist a decision maker, or a group of decision makers, in identifying the best alternative from a range of alternatives in an environment of conflicting and competing criteria and interests (Belton and Stewart, 2002).

4.2.2. DSS Design

Building upon the information acquired in the participatory activities carried out in the first two years of the project one new workshop was hosted by ICIMOD, and held in Kathmandu, Nepal (November 2009), with the aim of providing the project consortium with a more detailed definition of responses to cope with flood risks under the pressure of climate change, related to the Planning category. Due to the high participation of end users from the UBRB in general, and specifically from the Assam case study area, the symposium focused on the Assam State of India. However, all end users' opinion were collected, thus the outcomes can be generally thought as BRAHMATWINN outcomes.

The workshop activities have been carried out during the symposium in which end users of the final outcomes have been invited. This symposium is one of the dissemination activities organized by the BRAHMATWINN project partners to facilitate understanding of the project outcomes. During the symposium, in fact, possibilities of interaction between researchers and end-users were encouraged. The workshop, therefore, relied on the presentations during which an overview of the BRAHMATWINN activities was given.

Figure 10. Brainstorming session during the symposium, ICIMOD, Kathmandu 9 November 2009

The following presentations were made:

1. Downscaling of General Circulation Model predictions in the Himalayan region; Andreas Dobler (JWG Univ. of Frankfurt, Germany)
2. Assessment of the natural environment; Petra Füreder (Z_GIS, Univ. of Salzburg, Austria)
3. Modeling socio-economic vulnerability to floods: Comparison of methods developed for European and Asian case studies; Craig Hutton (GeoData Institute, Univ. of Southampton, United Kingdom) and Stefan Kienberger (Z_GIS, Univ. of Salzburg, Austria)
4. Analysis of present IWRM practices in the Brahmaputra basin; Anita Bartosch (FSU-Jena, Germany)
5. Identification and selection of indicators of environmental change; Valentina Giannini (Fondazione Eni Enrico Mattei, Venice, Italy)

6. Using the hydrological model DANUBIA for water availability scenarios in the upper Brahmaputra basin; Monika Prasch (LMU, Munich, Germany)

7. Stakeholder presentation to "Present IWRM in Upper Danube river basin"; Hans Wiesenegger (Government Salzburg)

8. Presentation of likely "what-if" scenarios in the UBRB; Prof Wolfgang Flügel (FSU-Jena, Germany)

Having introduced the project and its main outcomes, such as the climate change scenarios, a brainstorming session was conducted to elicit and consolidate the sets of possible **responses** within the Planning category. This section created the basis for the correct implementation of the ensuing steps, and led to the identification of specific actions, within the proposed broad Planning category of responses. The responses analysed were:

- DISASTER RISK MANAGEMENT
- FLOOD RISK ZONING FOR HAZARD PREVENTION
- LAND-USE PLANNING
- RELIEF AND REHABILITATION PLANS

Having consolidated the identification of responses, the participants were presented the **criteria** selected for the evaluation of responses, and the **indicators** chosen to describe each criterion. The criteria presented had been selected during the workshop held in Kathmandu in 2008, from the Sub-domains listed in the IIT created by the whole BRAHMATWINN consortium described in **Chapter 2**. The indicators have been chosen among those listed in the IIT, because judged the most fit to describe that specific criterion in the caste study.

Table 10. Selected criteria and relative indicators

THEME	CRITERION	INDICATOR
SOC 1	POVERTY	1. per capita income
SOC 2	POPULATION DYNAMCS	2. population growth; urbanization
SOC 3	INFRASTRUCTURE PRESSURES	3. measure of flood damage to property, to man, to cattle
ENV 1	BASIN MORPHOLOGY	4. stream bank erosion
ENV 2	FOREST MANAGEMENT	5. decline of per-capita availability of forest land
ENV 3	VULNERABILTY	6. potential erosion prone stream bank line
ECON 1	ENERGY PRODUCTION	7. construction of dams; use of dams for hydropower, water supply or both
ECON 2	AGRICULTURE PRODUCTION	8. growth of area and number of tea estates 9. gross irrigated area
ECON 3	EMPLOYMENT	10. share of secondary sector of GSDP; contribution of tertiary sector to NSDP 11. growth of industries

Indicators/criteria and **responses** were used to define the entries of the AM (9 rows and 5 columns for criteria and response categories respectively) and were utilised for the subsequent evaluation exercise, by means of the MCDA methods provided by the mDSS software. Participants were asked to fill in the **matrix** by evaluating the potential effectiveness of each response (columns) in coping with the issues expressed by the criteria (rows) by means of a Likert scale (from 1 to 5 ranging from "very high effectiveness" to "very low effectiveness"). Forms were distributed to all the participants with a specific question aimed at understanding the effect each response would have on each indicator (see Deliverable 10).

Moreover, in accordance with the "Guidance Notes for the lead authors of IPCC 4th Assessment Report on Addressing Uncertainties" (IPCC, 2005), a scale was added to the matrix to analyse the degree of confidence and uncertainty related to LAs' opinion. Here, the concept of uncertainty was related to the unpredictability of the effectiveness of the responses, which can be due to various reasons: e.g. the unpredictable projections of human behaviour, the unpredictable evolution of political systems, the chaotic components of the eco-system, etc. Thus, a second question, “What is your degree of confidence in giving your answer, considering its predictability?” was added to the form sheets and a second Likert scale was added in the AM.

The compilation of the AM concluded the NetSyMoD workshop. All the data collected were coded with a spreadsheet software and then passed to the mDSS tool, for MCA and GDM. The mDSS software allowed for the comparison of the alternative options using MCA techniques, by operating parallel evaluation processes, representing the preferences of each participant. The alternative options (i.e. the four categories of responses) were assessed on the basis of their contributions to solve the expected impact due to flooding under a climate change scenario, and expressed through the criteria values. The weights used for the MCDA were those elicited in the Kathmandu workshop held in 2008 (see Figure 11).

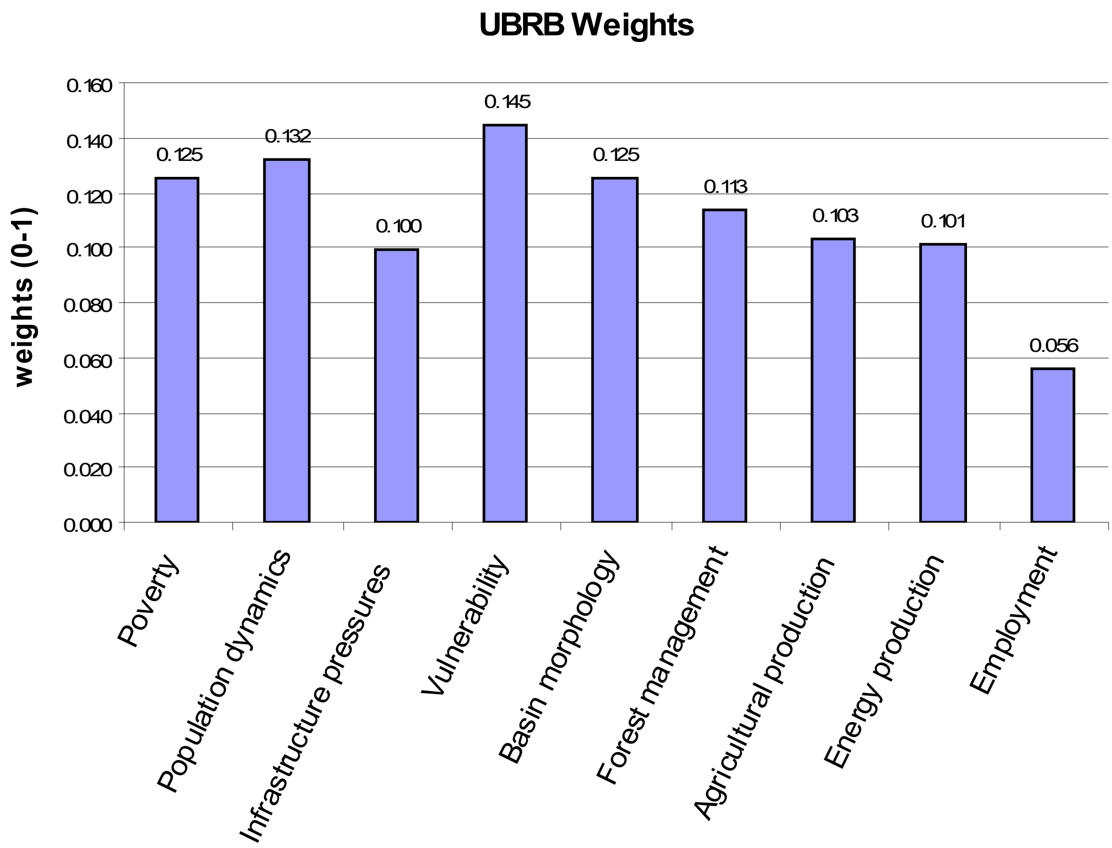


Figure 11. Weights attributed to criteria by LAs during the workshop held in Kathmandu in 2008.

In practice, the qualitative evaluations contained in the AM were transformed into scores that expressed the performances of the responses by applying a normalisation procedure, which converted them into a continuous scale from zero to one, subsequently processed by means of MCA decision rules. For the purposes of the workshop the Electre III decision rule was utilised to rank the alternative responses. Electre III adopts a pairwise comparison of the alternatives, so it is computationally rather demanding, but very simple to be applied by practitioners. It imposes so-called outranking relation on a set of alternatives. An alternative ***a*** outranks an alternative ***b*** if ***a*** is at least as good as ***b*** and there is no strong argument against. Results of individual outranking procedures were subsequently combined in a Group Decision Making procedure by means of the Borda rule. The Borda rule is one of the most simple outranking procedures and it is provided by the mDSS software, in which a total Borda mark is calculated by summing up all the (reversed) rankings obtained by the LAs (i.e. the best option is given, in this case, a value of 3, while the worst the fourth, is given a value of 0). The best (consensus) option is obviously the one with highest total Borda mark.

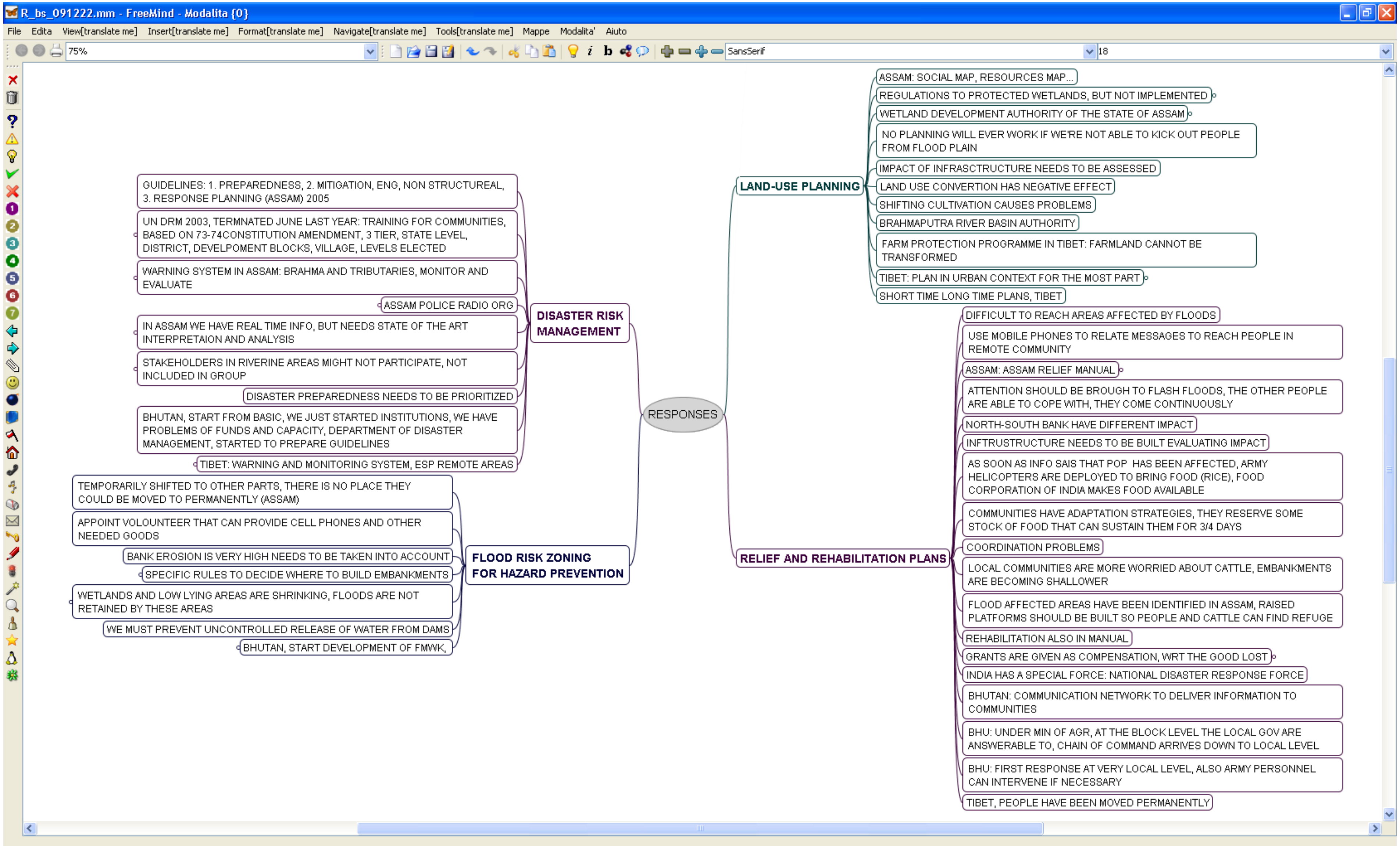


Figure 12. Specific actions for the implementation of responses, screenshot of FreeMind.

Table 11. Specific actions for the implementation of responses elicited from stakeholders, recorded with FreeMind as shown in **Figure 12**

1. DISASTER RISK MANAGEMENT		
	EXISTING	
A	44. flood guidelines	preparedness mitigation (engineering and non structural interventions) response planning
A	45. un disaster risk management programme	3 tier system task forces created for each district to create awareness response is effective training provided: first aid, for masons to build stronger buildings, programmes for engineers and architects protection of life, property and environment
A, T	46. early warning system	CWC collects data and to the state governments, which pass it to district authorities on Brahmaputra and tributaries, especially in remote areas of Tibet
A	47. information from assam police radio	people send information to police every police station has radio
A, B	48. communication network	• mobile phone network is needed (A) • reach communities in remote areas, which are cut off as soon as the flood happens (A) • deliver information to communities (B)
B	49. department of disaster management	recent establishment: started to prepare guidelines
	IMPROVEMENTS / DEMANDS:	
A, B	50. capacity building	
A, B	51. fund raising	
A	52. early warning system	• flood water warning system • early warning system on tributaries for cloud bursts and flash floods • modernize monitoring system for tributaries
A, T	53. communication network	• mobile phone network improvement (A) • temporary system is available, only for government level (T)
A	54. analysis of real time information	
A	55. disaster preparedness	
A	56. provision of cell phones and other goods	• appoint volunteers for provision

2. FLOOD RISK ZONING FOR HAZARD PREVENTION		
	EXISTING	

A	57. temporary resettlement of people	
B	58. development of framework	
B	59. glofs are a priority	
T	60. permanent resettlement of people	
	IMPROVEMENTS / DEMANDS	
A	61. take into account bank erosion	
A	62. specify rules for location of embankments	• define flood prone areas • calculate period of return(HQ) • superimpose weather prediction data to make decisions • map areas most prone to flooding
A	63. enable the use of wetlands as retention areas	• connect wetlands to river
A	64. control release of water from dams	
A	65. diverse landscape should be taken into account	• ranging from 4000 m, to 100 m foothills
A	66. need to include riverine populations	• difficult to reach them • some communities are not adapted and are hit hard
A	67. deal with embankments	• embankments are becoming shallower • people are worried
A	68. build raised platform refuges in flood prone areas	• raised platform are needed so people and cattle can find refuge
B	69. mitigation related to glofs	
B	70. protect cultural and religious sites and monuments	
B	71. protect hydropower plants	

3.	**LAND-USE PLANNING**	
	EXISTING	
A	72. social map	
A	73. resources map	
A	74. wetland development authority, state of assam	
T	75. urban planning	• mainly people live in cities
T	76. plans	• short and long time
T	77. farm protection programme	• farmland cannot be transformed • degradation affects grass land only
	IMPROVEMENTS / DEMANDS	
A	78. enforcement of law	• regulations to protect wetlands exist but are not implemented
A	79. understanding of wetlands	
A	80. regulatory measures to protect wetlands	• wetlands are reduced because of increase productivity
A	81. stop encroachment	• prevent construction in flood plain • assess impact of infrastructure • deal with shifting cultivation
A	82. stop siltation	• siltation disconnects water from river
A	83. brahmaputra river basin authority	• provide inter state Indian basin management

4. RELIEF AND REHABILITATION PLANS		
	EXISTING	
A	84. provision of food to flood afftected communities	• army helicopter are deployed to bring rice • National disaster response force also distributes food • Food corporation of India makes food available • communities have adaptation strategies: they reserve stocks of food that can sustain them for 3-4 days
A	85. assam relief manual	• instructions for natural disasters (1976) • information for different types of people (young, grownups…) • includes rehabilitation elements • CRF: 27 items, 25% Assam money, 75% State of India • funding scheme for flood affected people
B	86. chain of command	• under the Ministry of Agriculture • at the block level the local government is answerable to • it arrives at the local level
B	87. first response	• at very local level • army personnel can intervene, if necessary
	IMPROVEMENTS / DEMANDS	
A	88. assam relief manual	• establish a way to calculate compensation • develop more effective measures • develop funding scheme for people affected by erosion
A	89. pay attention to people affected by flash floods	• people affected by flooding have somewhat adapted • people affected by flash floods need to develop adaptation strategies
A	90. coordination is needed	
A	91. map existing assets	• documentation needed to allocate compensation equitably

In the first column the letter identifies the origin of the end user:

A: Assam
B: Bhutan
T: Tibet

4.3. Results

The end users present in the workshop took part in a very informative discussion, each contributing to it by sharing knowledge and understanding. The brainstorming was facilitated by Craig Hutton and Valentina Giannini, who was also registering the contributions by means of a freeware, FreeMind, which was projected on the big screen for everybody to see (see Figure 12 and Table 11). The goal of the workshop was to elicit what we have defined as actions, i.e. specific Integrated Water Resource Management Strategies that could be implemented under each response.

The brainstorming time, roughly two hours, was divided into four sections. During each the participants were asked to define and identify what kind of actions are existing or needed with reference to the four responses presented. It must be said that all actions were collected, and no statements were made as to preferences in this phase.

The use of a software for the registration is useful in many respects: (1) it enables the in time visualization of all that is being said, ensuring the right action was registered, (2) it creates a visual aid, i.e. a reminder for participants of what has been said, (3) it structures actions in the given framework, (4) it enables conversion of outcomes in a .html file, which can be then elaborated.

The further elaboration of the outcomes is necessary in order to systematize in a coherent way what was expressed. Repetition of similar actions, in fact, may occur. Also some actions that during the brainstorming were attribute to one of the proposed response, but were thought to fit better in another response, were moved. However, some of the actions are not easily attributed to one or the other response. Actions were also divided between: (1) existing and (2) needing improvement or demanded (see Table 11).

Most of the outcomes regard the Assam case study. However, some information was elicited from participants of the other case studies. The only European present, Hans Wiesenegger from Salzburg, gave a presentation during the symposium on water resources management in the municipality of Salzburg. Hans also intervened in the brainstorming sharing his experience. His contribution was much appreciated by the BRAHMATWINN research partners and by other participants.

Participants from Bhutan briefly, but effectively, described their country projects on water resources management, and environmental issues in general. They stressed the fact that in Bhutan they are just in the starting phase, therefore, many institutions are created or regulations defined, but little has been implemented, as of now.

The situation in Tibet is very different. The government seems to be well aware of the environmental problems, and very detailed plans are being implemented. Unfortunately, a very generic contribution was given by participants in the brainstorming, it would have been very interesting to learn more about implementation mechanisms, for instance.

Last but not least, the Assam State of India. Most of the words spoken in the brainstorming came from participants of this region. These participants were generally very well informed and thus their contributions were possibly of inspiration for the others. It emerges that a framework is in place, even if more needs to be done for the implementation and further specification of it.

However, the brief comments outlined here are based on the mere interpretation of the brainstorming outcomes. A more in depth analysis of the responses with respect to the governance framework was carried out by the University of Dundee in Deliverable 4 and Deliverable 8.

Our hope is that this brainstorming in particular, as well as the symposium in general, are seen as a good opportunity to share information and learn from each other, integrating knowledge from the different disciplines involved.

The analysis of the matrices compiled by the workshops participants was carried out with the mDSS software. First of all a file was created where the **indicators** (rows of the matrix) were loaded and attributed to the DPSIR framework. In the same file IWRM **responses** (columns of the matrix) analyzed were loaded (see Figure 13).

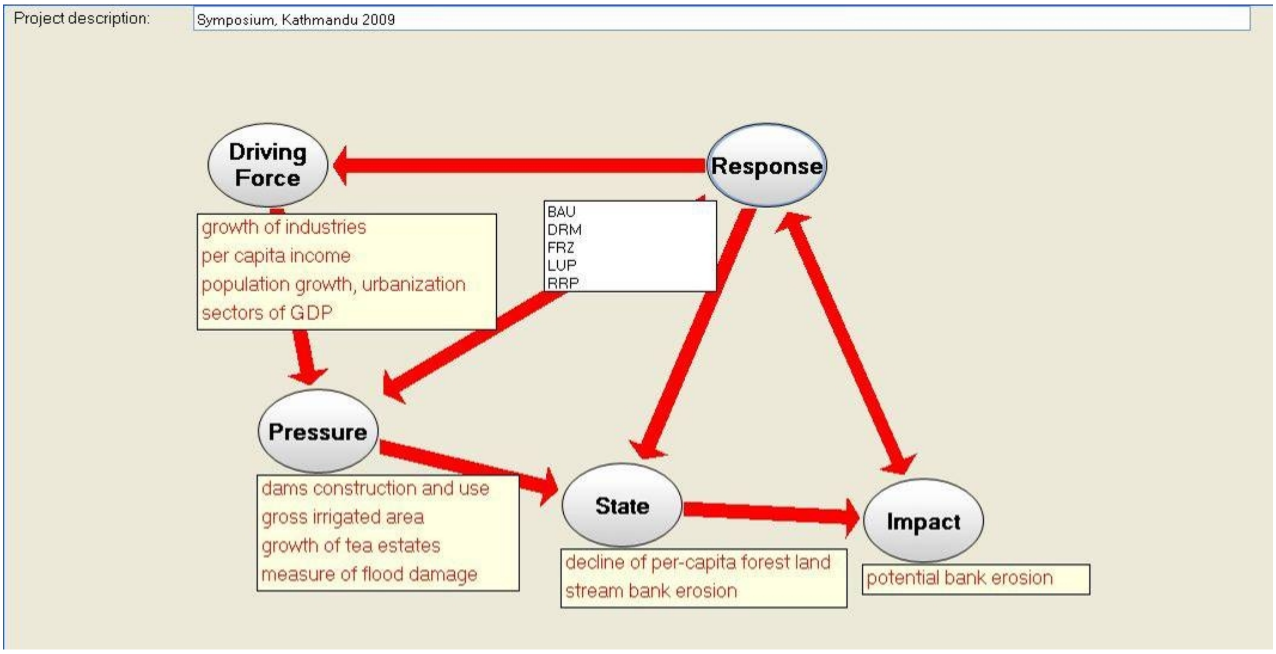


Figure 13. Screenshot of mDSS with indicators attributed to DPSIR framework

Figure 14. Screenshot of mDSS with ranking obtained with the Electre III method (average matrix)

Then each matrix compiled was input into the mDSS, and analysed with ELECTRE III. Also a matrix with the averages was input into mDSS. To enable the ranking, the vector of weights, created in the previous Kathmandu workshop (2008) was loaded. Three outranking procedures are available: (1) descending, (2) ascending, and (3) intersection (see Figure 5, top left, top right and bottom, respectively). If we consider the matrix containing the average of the scores attributed by each participant, we see that Land use planning wins, regardless of the method applied!

Another option given in mDSS is the comparison of each participant's votes. This is done in the Group decision – Compromise function. After elaborating each participant's matrix, output option files are created, which are later loaded in the Group decision – Compromise section. Three rules can be used: (1) Condorcet, (2) Borda, and (3) Extended Borda. Each rule can be applied to the descending, ascending or intersection outranking procedures, generating nine rankings (see Figure 15 to **Figure 23**). This analysis confirms Land use planning as the preferred responses, thus assessing the robustness of this choice.

4.4. Conclusions

Since participatory processes, where power is equally shared and expression of all opinions is facilitated, are increasingly being included in good governance principles (De La Vega-Leinert et al., 2008; Reed, 2008; Griffin, 2007), by choosing this methodology, we were able to include many LAs that have a stake. It was possible to compare several opinions. Moreover, since the goal of the process was not consensus building, we were able to consider and compare all opinions, avoiding the loss of minority views, e.g. those of less empowered stakeholders (Griffin, 2007). In our case, on the contrary, end users have been invited because they represent all issues at stake, and all opinions they expressed have the same importance.

Last but not least, local actors who participated in the workshop (e.g. mainly end-users of research outcomes) gave a positive evaluation of the BRAMATWINN research, in general, and of the NetSyMoD framework, specifically filling in a questionnaire, validating this methodology.

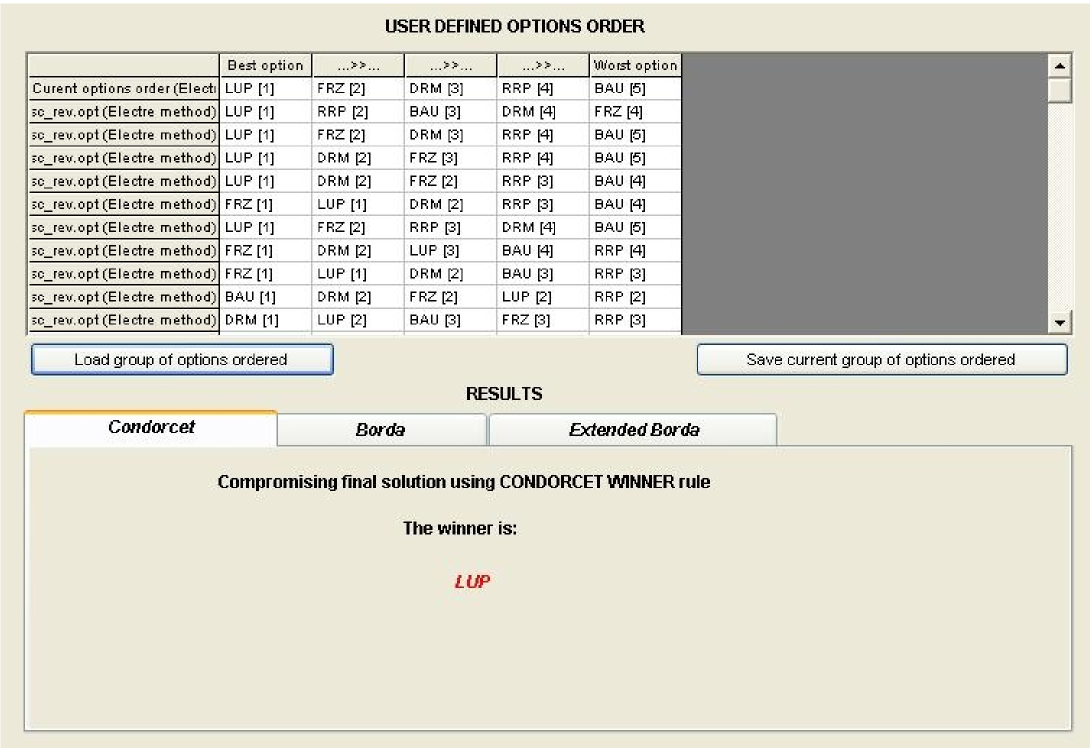


Figure 15. Screenshot of mDSS: compromise solution based on descending order with Condorcet rule

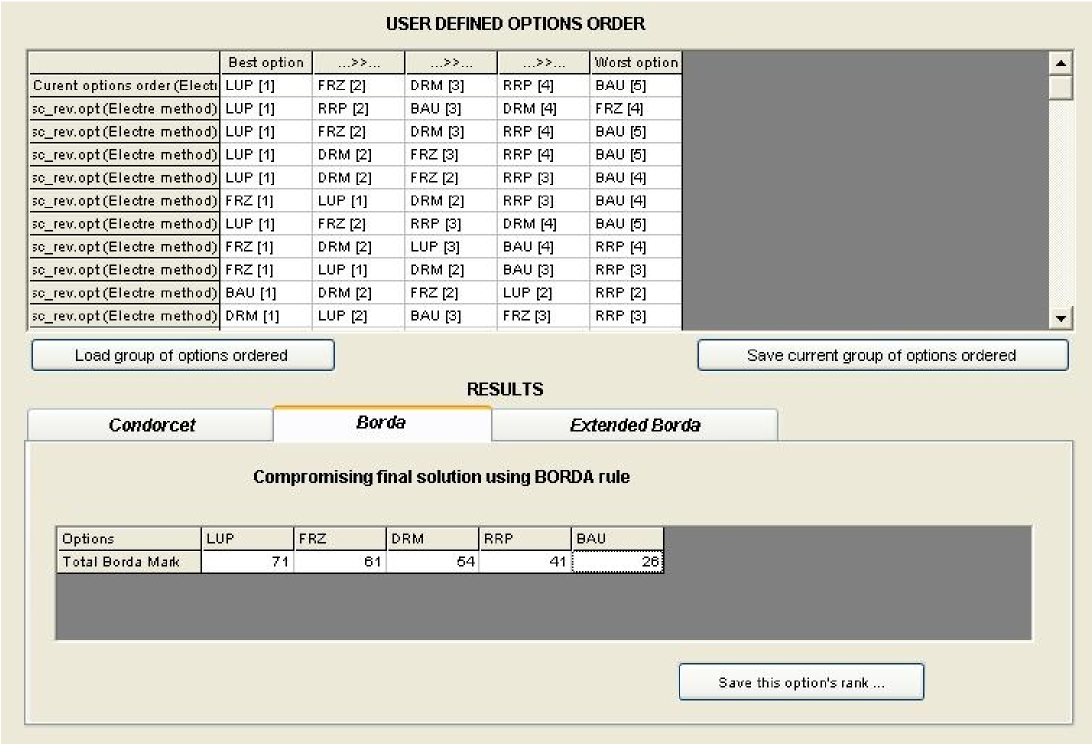


Figure 16. Screenshot of mDSS : compromise solution based on descending order with Borda rule

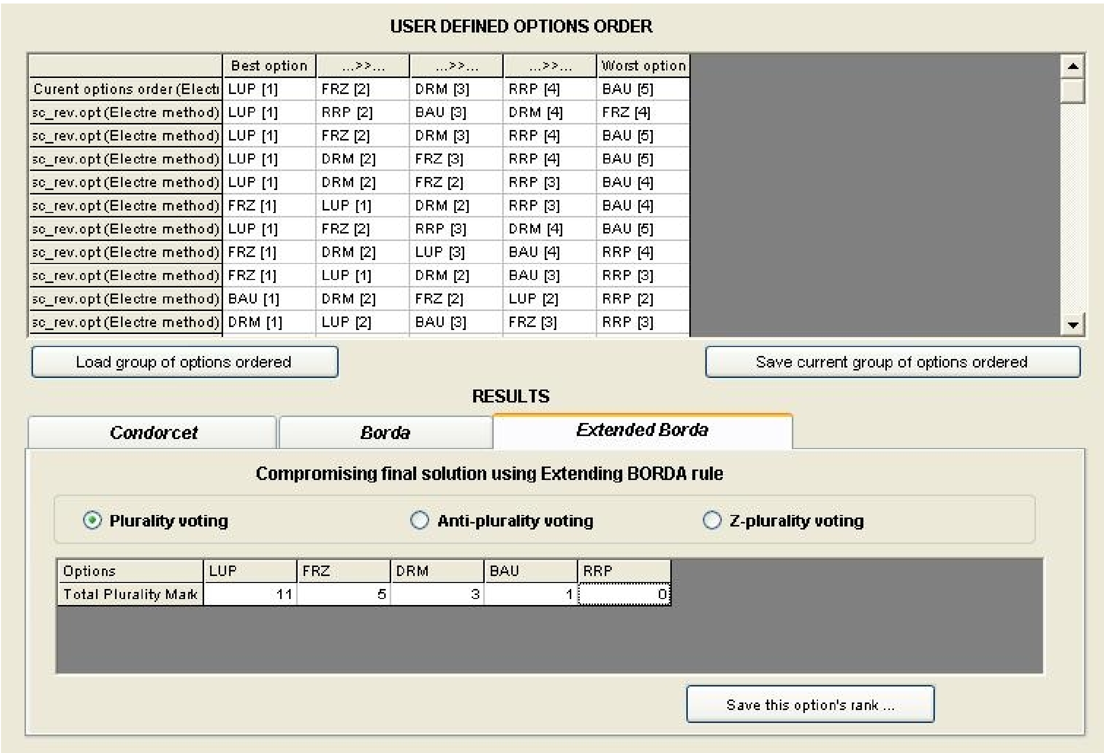
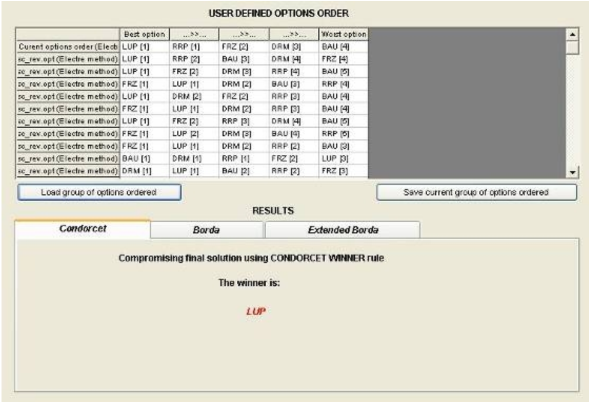
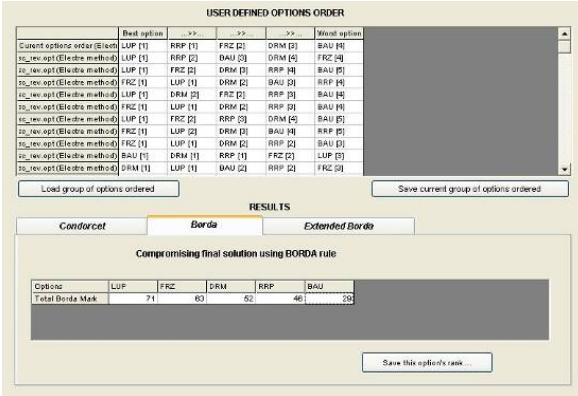


Figure 17. Screenshot of mDSS : compromise solution based on descending order with Extended Borda rule





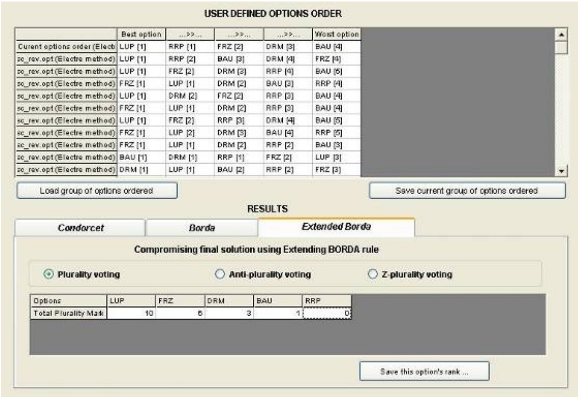
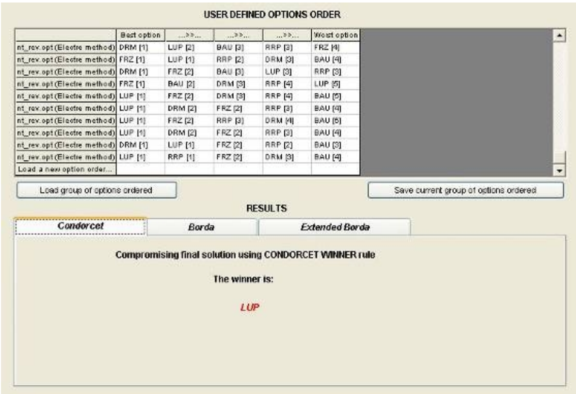
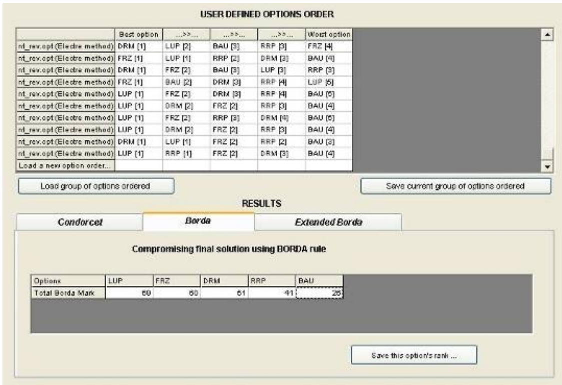


Figure 18. (top left) Screenshot of mDSS: compromise solution based on ascending order with Condorcet rule

Figure 19. (top right) Screenshot of mDSS : compromise solution based on ascending order with Borda rule

Figure 20. (bottom left) Screenshot of mDSS : compromise solution based on ascending order with Extended Borda rule





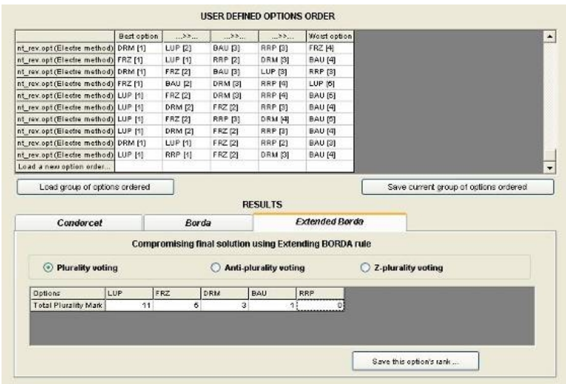


Figure 21. (top left) Screenshot of mDSS: compromise solution based on intersection order with Condorcet rule

Figure 22. . (top right) Screenshot of mDSS : compromise solution based on intersection order with Borda rule

Figure 23. (bottom left) Screenshot of mDSS : compromise solution based on intersection order with Extended Borda rule

5. CHAPTER 5 IMPROVING WATER GOVERNANCE THROUGH SCIENCE AND STAKEHOLDER DIALOGUE: EXPERIENCE FROM ASSAM (NORTHEAST INDIA)[29]

5.1. Introduction

5.1.1. Background

Future climate change scenarios can be modelled, but a degree of uncertainty remains. Nevertheless, there is reasonable convergence within the international research community on a series of significant impacts that can be expected to occur on the social and ecological systems (IPCC 2007a). Those impacts will modify the structures and functions of the ecosystems and the services they provide, as well as the hydrological regimes and water quality and quantity, thus altering, for example, the regulating services for floods. Ecosystem changes, in turn, will have an impact on the human dimension, i.e. on the local populations that will have to bear the consequences of and try to adapt to the climatic changes and their associated impacts. The need thus emerges to develop holistic approaches to allow for the incorporation of knowledge from different sources (scientific, empiric, historic, local) and different perspectives to assess the potential effectiveness of adaptation measures to climate change (IPCC 2007a) in response to the expected impacts. Because of the complexity and relevance of water management, it is necessary to support the development and the implementation of adaptation policies and response strategies to cope with the current and future expected impacts of climate change.

This need is also driven by the increasing public awareness of the potential impacts of global warming. The upper mountain regions of the globe, including the Himalayas, are affected by climate change (Armstrong 2010; Frauenfelder and Kääb 2009). There is, however, some degree of uncertainty in the predictions of future climate scenarios, nevertheless, this must not be an excuse for inaction: policy objectives must be clarified and priorities set. Thus, on the one hand, the collaboration between LAs and scientists seems to be a way to analyze local issues and propose new management options to cope with global change, meaningful for the specific case study (Walker et al. 2002). The dialogue between LAs and scientists can be enhanced through empowerment and information sharing; LAs and scientists can work together and contribute to the decision making process (IPCC 2007b). On the other hand, opportunities for bridging the gap between scientific and policy communities (IPCC 2007c) must also be explored.

Moreover, LAs, representing the local populations who are bearing the burden of climate change, will be those required to implement adaption responses to the changing climate. They should therefore be involved in the associated decision making process (IPCC 2007b). The LAs in the participatory process described here are stakeholders, policy and decision makers, local scientists, experts, and civil society groups. The participation of LAs anchors responses to local knowledge and needs, whilst providing a high potential for sustainability. Getting LAs involved is also one of the seven key aims of the European Water Framework Directive (WFD - Dir. 2000/06/EC), and more broadly a key aspect of the concept of IWRM (see Global Water Partnership 2000).

There are at least two main reasons supporting the inclusion of LAs' opinions in the decision making process. Firstly, public participation is needed to balance the interests of various groups. Secondly, LAs' involvement might enable greater implementation and enforcement possibilities. If LAs, in fact, are involved in decision making, transparency will be achieved by means of consultation and information processes. Also, if LAs' opinions are taken into consideration in the decision making process, and its outcome reflects their contribution, they could be more willing to abide by it.

[29] THIS CHAPTER HAS BEEN PUBLISHED AS IS IN CMCC RESEARCH PAPER SERIES
Giannini, V., and Giupponi, C. (2011) Improving water governance through science and stakeholder dialogue: experience from Assam (Northeast India). CMCC Research papers RP0115.
my contribution: design of the framework for the gap analysis: knowledge flow and integrated indicator table, parts of discussion and conclusions.

5.1.2. BRAHMATWINN: case study presentation

The research project BRAHMATWINN[30] was funded by the EU's Sixth Framework Programme in the context of stakeholder engagement for climate change decision support; Beginning in June 2006 and ending in December 2009, BRAHMATWINN aimed at enhancing and improving the capacity to carry out adaptive and harmonised IWRM approaches in headwater river systems affected by climate change. The project specifically addressed the impacts and causal relationships of climate change on hydrology, water quality and availability, land use dynamics, socio-economic processes, and legal frameworks. The research partners involved worked to understand the impact of climate change in five case study areas: two in the Upper Danube River Basin, the Lech and the Salzach River Basins (Austria and Germany); and three in the Upper Brahmaputra River Basin, Assam in India, the Wang Chu River Basin in Bhutan, and the Lhasa River Basin in the Tibet Autonomous Region of China. Only one out of the five case studies will be taken into consideration in this article: the Assam State in India. This is mainly due to data availability: not all the five case studies of the BRAHMATWINN project were developed with the same depth because of time and resources constraints.

Climate simulations using three IPCC-SRES scenarios (A1B, A2 and B1) and the Commit scenario (i.e. the consequence of committing world economies to limit GHG concentrations at 2000 levels), five data sets (GPCC, UDEL, CRU, EAD, F&S) and four models (ERA40, CLM-ERA40, ECHAM5, ECHAM5-Γ), have been run and downscaled for the five case study areas (Dobler et al. 2011). Preliminary projections in both European and Asian regions imply a future where change will not be straightforward, but will instead exacerbate climate events already being observed, i.e. increase in the intensity of rainfall, and increase in severity of droughts during dry periods (Dobler et al. 2011). The downscaled climate scenarios were used as input to run the Danubia Model, a coupled simulation model which is able to integrate interdisciplinary results to develop scenarios (Prasch et al. 2011). All the information produced by the BRAHMATWINN research consortium was then stored in the River Basin Information System and made available within the BRAHMATWINN research consortium.

Throughout this process there was the need to find a correspondence between LAs and research scientists to produce shared knowledge and inform both the research activities and the policy making process. Integration is a necessary goal of any project that deals with natural resources management, especially to cope with changing social-ecological systems.

Based on the outcomes of BRAHMATWINN an approach was tested to produce the direct benefits for the end users: recommendations were developed keeping in mind both the specific situations of case studies, and the general global practice of IWRM and flood management.

In this paper we present the working phases that were aimed at providing a platform to allow communication within the research partners, and among research partners and LAs. Further research activities were carried out to capitalise, gain insights and consolidate the results of the project and derive a methodological proposal for future research. In **Paragraph 5.2** we describe the framework of the Integrated Indicator Table (IIT), the methodology used to define governance scores, and to perform the gap analysis. In **Paragraph 5.3** we describe how the gap analysis was applied in the BRAHMATWINN project in order to analyse responses within a governance framework. **Paragraph 5.4** discusses results, and **Paragraph 5.5** concludes by outlining some possible recommendations.

5.2. Methods

5.2.1. Knowledge flow and structure of the Integrated IndicatorTable

Figure 24 describes the knowledge flow that led to the integration of the BRAHMATWINN research results, which are stored in the River Basin Information System, and used for the gap analysis described in this paper.

One of the BRAHMATWINN research consortium's expected outcomes was to produce knowledge addressing LAs' expectations and needs. Several rounds of consultation were organized so that research partners and LAs could share their knowledge, while at the same time expressing their needs and expectations. Several workshops were carried out, during which both BRAHMATWINN and LAs identified and addressed knowledge demand and supply, generating the knowledge flow represented in Figure 24.

[30] For a complete overview of BRAHMATWINN's outcomes see Advances in Science & Research – Volume 7 (2011), accessible online at http://www.adv-sci-res.net/7/index.html [last access June 2011]

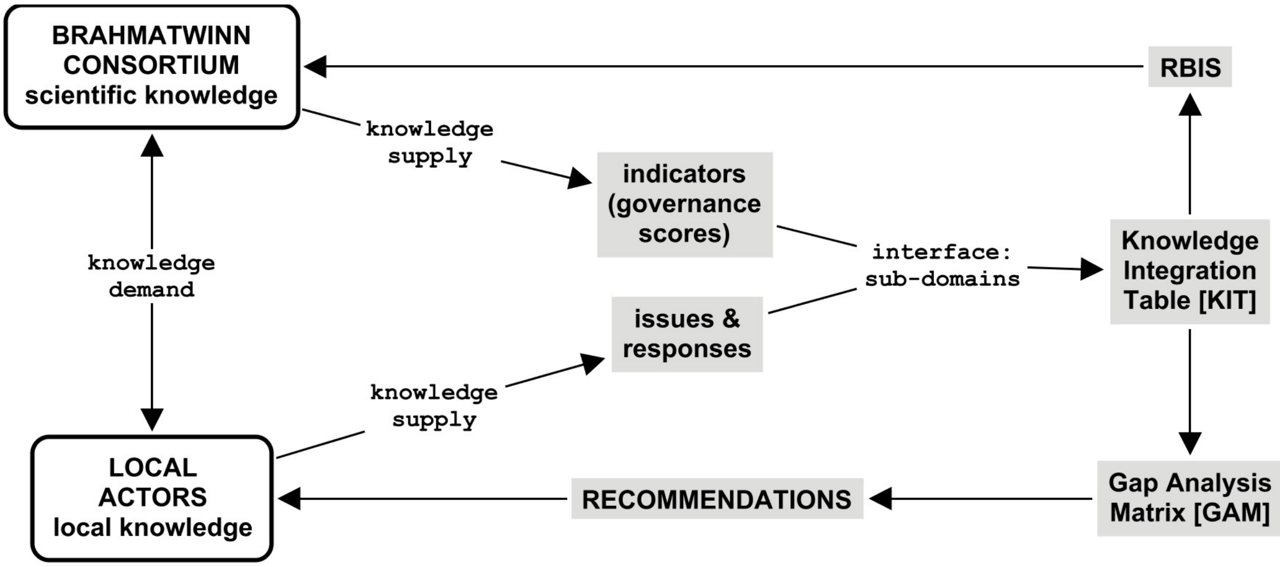


Figure 24. Knowledge flows within the BRAHMATWINN Project.

As a result, a very extensive table was designed with the aim of improving communication between researchers and LAs, including governments. The table had two specific objectives: (1) to provide a synoptic view of the expected intermediate products of the various disciplinary fields, i.e. a catalogue of indicators and metadata; and (2) to compare and integrate the previous component with the structured outcomes of the activities carried out with LAs. Regarding the first objective, it should be remembered that the BRAHMATWINN research consortium was made of 17 different partners, representing all the disciplinary fields needed for IWRM. Thus the need emerged among research partners to design a table of indicators, which would list all those used or identified by each research partner, to enable consultation and interaction. Regarding the second objective, the main need was to provide a systematic reporting of the outcomes of a series of workshops organised in the five case studies, all contributing to the analysis of local issues, expectations and preferences about the present state and future trends of the river basins' water resources. Given such contents the table was called the IIT.

Therefore, two processes were merged: one research-driven, the other LA-driven (Ceccato et al. 2011; Giannini et al. 2011). The structure of the IIT is thus constituted of two sides. The left hand side lists the qualitative and quantitative indicators identified by the research partners. The right side lists the local issues and response strategies needed, or in place, identified by the LAs during the workshops. The interface between indicators and issues/response strategies takes place through a framework (Theme, Domain, Sub-Domain), which has been created specifically to facilitate this link (Ceccato et al. 2011; Giannini et al. 2011). A biunivocal relationship between the two sides is established through each Sub-Domain, which is linked to each group of indicators (left side) and to each group of issues/responses (right side). This facilitated knowledge exchange between and within project partners, on the one side, and between project partners and LAs, on the other side. Very importantly it also allowed for the identification of gaps in the information structure of the project: local issues which were not dealt with by any indicator, thus demonstrating that some relevant problems or specific aspects could not be quantitatively assessed by the project activities and, on the other side, that some indicators offering the opportunity to assess issues were not mentioned as relevant by the LAs.

The elicitation of issues and responses was carried out as one intermediate step of the implementation of the NetSyMoD approach (Giupponi et al. 2008) for participatory modelling and decision support during a dedicated workshop. Through brainstorming sessions during the CSM workshops, issues affecting the project case study areas were elicited from the LAs involved, and existing or needed responses to cope with them were discussed, thus building shared visions and common understanding of the problems. The consolidated list of issues and responses collected during the CSM workshops carried out in Assam (April 2007), Bhutan (October 2007), Austria (October 2008), Nepal (November 2008) and Austria-Germany (February 2009) has been processed and included in the IIT. Subsequently it was also used to assess the expected effectiveness of the responses to cope with flood risk under climate change impacts, by implementing the NetSyMoD phases of DSS Design and Analysis of the Options (see Ceccato et al. 2011).

Indicators were identified through a sequence of three consultations, which were carried out with project partners to populate and validate the left side of the IIT. The first was carried out by distributing a template for the collection of the indicators to each partner. The other two resulted in the consolidation and validation, respectively, of the IIT by the project partners.

The two parallel processes were organized in such a way as to enable information exchange between the two, e.g. the issues and responses identified by LAs could be expressed and measured through the indicators identified by project partners. As previously mentioned, a rough measure of the adequacy of the knowledge produced by the project partners with respect to the issues identified by the LAs, derived from the extent of the match between the left (researchers') and right (LAs') sides of the IIT.

A final version of the IIT was presented at the last workshop (Kathmandu, November 2009). The LAs and the researchers were given the possibility to confirm their final validation, and the IIT was then used for the governance gap analysis reported below.

5.2.2. BRAHMATWINN: governance scores attribution

During research carried out in the initial phases of the BRAHMATWINN project a series of qualitative governance indicators were developed by Andrew Allan and Alistair Rieu-Clarke from the University of Dundee. In this article these qualitative governance indicators have been used to assess the effectiveness with respect to the possibility of coping with flood risk, of the governance regime in place in the case study area. We will briefly review here the methodology used for their development as described in the deliverables written for the BRAHMATWINN project. Should the reader be interested in knowing more about this research, reference should be made to the following articles: Allan and Rieu-Clarke 2010; Hutton et al. 2011; and Rieu-Clarke et al. 2010.

These indicators of effective governance considered the fact that implementation of the law rarely matches the letter of the legislation, and therefore evaluated both the content of the relevant law (UNDP, 2004), and the degree to which it appeared to be applied in reality (Allan and Rieu-Clarke 2010). The indicators assessed factors beyond those simply related to water, taking the view that as the broader governance framework would have a significant impact on whether or not water resource management was effective, wider issues of transparency, accountability, participation and predictability should be measured (Hutton et al. 2011). In this context, predictability was used as a proxy for IWRM, so the assessment exercise in fact included a detailed analysis of the governance and management framework in place for water resources management. A model answer was developed for each qualitative indicator, following the methodology used by the World Bank in its Country Policy and Institutional Assessment process (World Bank 2005), and broadly reflecting what might be considered as international best practice in each case.

The resulting series of fifteen broad indicators (see Rieu-Clarke et al. 2008) has thus been acquired and is listed in Table 12, which is coherent with the framework presented in **Paragraph 5.2.1** above. The qualitative indicators were then applied to the case study areas to highlight the strengths and weaknesses of each governance framework and to identify areas of concern – for example where there were wide disparities between what the law said and the reality of its implementation, or where the law in place was inadequate when compared with what might be expected by international best practice. Scores were allocated for each of the many sub-questions, assessed against the model answers for each indicator, and these were combined to produce composite scores out of 100 for each of the four principal areas (i.e. transparency, accountability, participation and predictability).

For each of these principal areas therefore, composite scores were derived to indicate firstly the state of the law as it is written, and secondly, the extent to which it appears to be implemented. Table 12 also highlights the relation that was made between these governance indicators and the suggestions from stakeholders at the CSM workshops that indicated what they believed the priority responses should be. The bridge between them consists of the Sub-domain column. The CSM Workshop responses are discussed in **Paragraph 5.3** below. As will become clear in the Gap Analysis, no equivalence is suggested between the expert-derived qualitative indicators and the stakeholder responses, merely a relation, albeit a resonant one in many cases.

Table 12. Governance indicators and scores with associated responses as elicited during the BRAHMATWINN workshops, extracted from the IIT, includes responses from all case studies of BRAHMATWINN.

Theme	Domain	BRAHMATWINN RESEARCHERS: indicators	Score [%]: law	Score [%]: imple-mentation	Sub-Domain	LOCAL ACTORS: responses
GOVERNANCE	Education	(1) Availability of environmental information to the public where requested, including actual copies of the documentation containing or comprising such information.	84	60	Increase knowledge	Integration and coordination among different sectors of research and decision making; Increase awareness and knowledge on best practices and research on impacts of natural hazards; Environmental monitoring; Flood modelling; Dissemination of knowledge; Educational policy.
		(2) Clear and coherent roles and responsibilities for the effective collection and generation of information related to IWRM and Climate Change.	52	68		
		(3) Clear and coherent roles and responsibilities for the effective exchange of data and information relevant to IWRM and Climate Change.	49	40		
	Institutional and legislative frameworks	(4) Rights of stakeholders established and maintained, including civil society organisations, and disadvantaged or underrepresented groups to participate in decision-making	77	43	Public Participation	Improve community involvement and foster participatory processes for decision-making, policy-making and implementation of laws; Foster livelihood practices as long-term practices, based on conservation, rehabilitation and sustainability.
		(5) Consultation of citizens actively sought by government institutions on policy issues, budgetary priorities and development decisions	80	63		
		(6) Effective participation of all stakeholders, including civil society organisations, in water and flood management	43	20		
		(7) Water management conducted in accordance with IWRM	25	18	IWRM /NRM	Establishment of institutions; Resolve conflicts and strengthen coordination among institutions; Protection of communities; Early Warning systems; River training works; Multi-purpose dam construction; Control of GLOFs; Channel improvement; Agricultural practices; Relief and rehabilitation.
		(8) Clear rights and obligations in relation to IWRM and Climate Change	33	15		
		(9) All relevant risks are taken account of and mitigated in flood planning	17	9		
		(10) Effective emergency alleviation and response system that limits risk and protects people, property and environment?	61	38		
		(11) Flood risk taken into account in broader land / water use management and environmental impact assessment	24	8		
		(12) Enforceable and adequate rights of access to information (including environmental information)	97	70	General institutional and legislative frameworks	Accountability and transparency in government actions; Implement and enforce existing laws and design new and more effective laws; Inter-state coordination and conflict resolution, cross-boundary issues.
		(13) Civil society access to redress and remedy	94	49		
		(14) System to challenge a law on the basis that it violates international law or the constitution	88	70		
		(15) Checks and balances between different branches of government	88	70		

5.2.3. Gap analysis

The information stored in the IIT led to the creation of the Gap Analysis Matrix (GAM). According to the methodologies described in **Paragraph 5.2.1**, the relevant elements were taken from the IIT to create the GAM (see Figure 25): governance indicators defined by project partners and response strategies identified by LAs were taken to compile the GAM. In effect the GAM turns the IIT around, so that instead of trying to match LAs' views with those of the project partners, the GAM takes as its starting point those responses identified by LAs in the Assamese workshop (April 2007).

The rows of the GAM are aligned with the responses that were elicited from LAs in CSM workshops. The columns take and develop the scores set out in Table 12. Since, as discussed below, a direct import of these scores was not possible, because of the absence of an equivalence between the responses and the indicators, each indicator was attributed to one or more response as shown in Table 13. The elaboration of this framework allows the reader to see the extent to which the governance framework actually corresponds with what stakeholders believe is necessary. Governance indicators are used to assess the gaps in the governance, and this enables measurement of how far governance has defined an effective response. A gap is identified when there is no effective governance response corresponding with the need identified by the LAs. This might take the form of the lack of an effective and relevant provision in law, poor institutional coordination, or no government commitment in the form of an appropriate policy statement that post-dates the last relevant legislation. Ultimately, scores have been attributed by authors interpreting and elaborating the opinions expressed by LAs during CSM workshops to test the GAM.

An initial effort had to be made to determine which of the governance indicators were most relevant with respect to each response, because the stakeholder responses, upon which the table is based, do not match perfectly the various governance indicators. This happens because two research streams carried out independently were merged. For example, with respect to the response "Community involvement in decision-making", this has relevance to the following governance indicators:

- Rights of stakeholders established and maintained, including civil society organisations, and disadvantages or underrepresented groups to participate in decision-making;
- Consultation of citizens actively sought by government institutions on policy issues, budgetary priorities and development decision;
- Effective participation of all stakeholders, including civil society organisations, in water and flood management;
- Civil society access to redress and remedy.

The scores for each of these indicators were calculated averaging the relevant indicators. These average figures were then entered into the governance columns of the GAM. This was repeated for each of the responses until the table was fully populated.

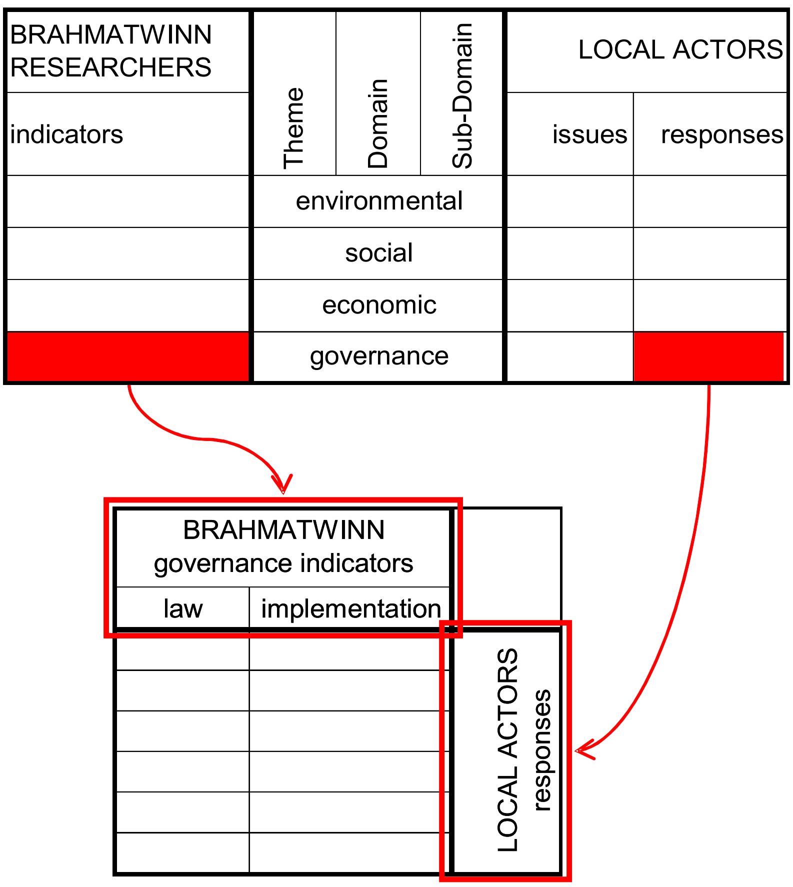


Figure 25. Scheme for the creation of the GAM and development of recommendations. Top: IIT; bottom: GAM.

Table 13. Attribution of BRAHMATWINN researchers' governance indicators to LAs' responses for the definition of the scores: an X marks the link, i.e. which indicator is used to assess each response with respect to the governance frameworks, Assam State only (see Table 12 for legend of indicators).

BRAHMATWINN RESEARCHERS: governance indicators															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	LOCAL ACTORS: responses
			X	X	X							X			Community involvement in decision making
									X						Early Warning System
								X	X						Protection of communities
									X	X					Relief and rehabilitation
						X	X	X							IWRM
X	X			X	X							X			Awareness of the population on risks, conservation, and WRM
						X									Establishment of institutions
			X	X											Policy making and implementation of laws
							X			X				X	Coordination among institutions
			X	X	X	X				X	X				Long-term vision and measure VS. short-term engineering solutions
		X				X							X		Inter-state conflict, cross boundary issues

5.3. Results

By comparing the responses identified by LAs with the governance scores attribution (**Paragraph 5.2.2**), it is possible to assess governance needs with respect to the vulnerability to flood risk. The result of the gap analysis, in fact, from the governance perspective, was to highlight those policy areas where gaps are found between what LAs expressed during the workshop, i.e. response strategies needed, and the governance situation as it currently stands. The GAM (see Table 14) outlines the combined scores from the governance assessment in **Paragraph 5.2.2** above, through the filter of the responses identified by LAs in the CSM workshops.

It is clear that the bulk of the responses identified by LAs have been valued in the governance assessment as being potentially problematic in Assam. Thus, in general, we can say that strengthening and improvement of responses, or of their implementation, is needed. That stakeholders should be raising questions with regard to community participation, however, in spite of the fact that many rights, obligations and powers already exist in law hints at problems with lack of awareness, or lack of faith in the system's capacity to provide access to redress or remedy, issues that have both been recognized in the lower implementation scores (Allan and Rieu-Clarke 2008).

Table 14. GAM: average scores of governance indicators.

BRAHAMATWINN RESEARCHERS: governance indicators		
law [%]	implementation [%]	LOCAL ACTORS: responses
73	44	Community involvement in decision making
61	38	Early Warning System
39	23	Protection of communities
43	23	Relief and rehabilitation
25	14	IWRM
70	52	Awareness of the population on risks, conservation, and WRM
25	18	Establishment of institutions
78	53	Policy making and implementation of laws
48	31	Coordination among institutions
58	37	Long-term vision and measure VS. short-term engineering solutions
54	43	Inter-state conflict, cross boundary issues

The exercise underlines a number of key deficiencies in relation to the other governance element, the water management context in Assam, both in terms of the quality of the policy context and also in relation to the issues that are neglected at the institutional, legal and policy levels. Table 14 also suggests, however, that awareness of the risks of floods and water resource management among other issues, has actually been tackled well. As a caveat to this, however, it is essential to note that direct comparison between the broad questions asked in the governance assessment and the responses highlighted by stakeholders is difficult, and the scores above give no impression as to the efforts that are ongoing to address particular areas of concern. By way of example, "policy making and implementation of laws" in Table 14 looks to be relatively successful both with respect to legal commitment and to implementation. Given the breadth of this issue, though, and the fact that the vast majority of the other issues raised suffer from significant gaps between commitment and implementation, one might expect the policy environment to take heed of the potentially significant problem of implementation. Unfortunately, the evidence from the eleventh Five Year Plan and from the priorities of the Indian Law Society, for example, does not appear to back this up (Allan and Rieu-Clarke 2008). It is also interesting to note the disparity between the extent to which IWRM is in place in law, and the awareness of the risks of flood and water resource management issues. The fact that awareness appears to be so high raises questions as to why the water management system remains so poorly rated and why comprehensive legislative reaction has been so slow. Finally, Assam was given low scores in terms of coordination – firstly, between relevant management institutions, and secondly between the riparian Union and Nation states on the Brahmaputra river. This concern has a direct relation with the degree to which IWRM is perceived to be in place: the question of whether India should tackle institutional coordination first, before enacting IWRM-led legislation, or vice versa must be addressed as a matter of urgency.

5.4. Discussion

Ranking the results according to the scores we can look at the responses with the worst scores, i.e. the responses which, according to our definition, have the highest gap with respect to design of law and implementation. These are (from the bottom):

1. IWRM
2. Establishment of institutions
3. Protection of communities
4. Relief and rehabilitation
5. Coordination among institutions

As we can see from Table 13 all but one (i.e. "establishment of institutions") have been calculated averaging two or three governance indicators. Some interesting insights have been found looking at the single indicators which compose them (see Figure 26). For three responses, namely (a) "protection of communities", (b) "relief and rehabilitation", and (c) "coordination among institutions" , the values of one of the two indicators used are quite high if compared to the values of the other indicators. The bad performance is due to the following governance indicators, respectively:

a) (9) All relevant risks are taken account of and mitigated in flood planning
b) (11) Flood risk taken into account in broader land / water use management and environmental impact assessment
c) (8) Clear rights and obligations in relation to IWRM and Climate Change
   (11) Flood risk taken into account in broader land / water use management and environmental impact assessment

While the fourth, "IWRM", is the result of the average of three governance indicators with poor values:

- (7) Water management conducted in accordance with IWRM
- (8) Clear rights and obligations in relation to IWRM and Climate Change
- (9) All relevant risks are taken account of and mitigated in flood planning

One can see how these indicators reflect, in fact, a generally poor performance of all indicators relative to flood management. Looking at the single governance indicators relative to the Sub-domain "IWRM-NRM" (Table 12) this comes as no surprise since this is the Sub-domain with the lowest values. One could therefore conclude that policy sectors which need strengthening are those related directly to flood risk management. However, it must also be noticed that the governance indicator "(10) Effective emergency alleviation and response system that limits risk and protects people, property and environment", also related to the Sub-domain "IWRM-NRM", features quite well when compared to all the other governance indicators, being the eighth value in "law" and the tenth in "implementation" (out of fifteen). Thus, possibly, emergency response issues in Assam are not a priority with respect to the existence of law, on the other hand more should be done with respect to implementation.

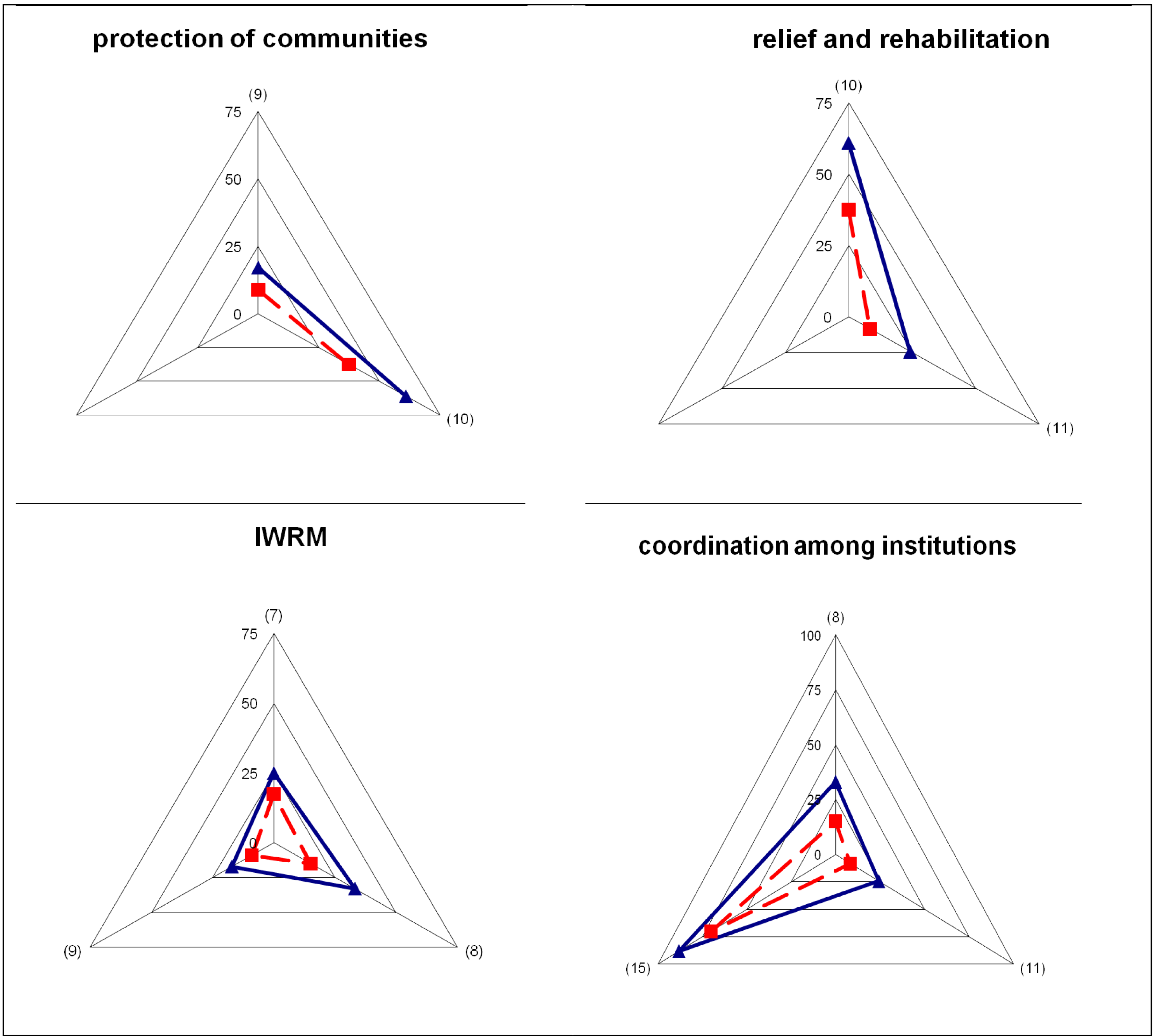


Figure 26. Responses scoring: single governance indicators attributed to each response are shown (solid blue lines and triangles: law; dashed red lines and squares: implementation).

Moreover, the governance indicator “(15) Checks and balances between different branches of government” as all other governance indicators relative to the Sub-domain “general institutional and legislative frameworks” features very well: third in “law” and first in “implementation”. The Sub-domain “general institutional and legislative frameworks” is, in fact, the one with the governance indicators that have the highest values (Table 12). So little improvement is requested on this issue.

5.5. Conclusions

The study was aimed at understanding how the information collected and elaborated during the research could be used to identify governance gaps in water and flood management, and thus provide recommendations for improvement in the IWRM governance framework. The BRAHMATWINN research project provided insights relative to the three pillars of sustainability, i.e. environment, society, economy, in addition to governance, which are listed in the IIT and matched to LAs’ issues and responses. Selected information from the IIT was used to create a GAM, where responses to address flood risk identified by LAs were evaluated against governance indicators extracted from the

IIT. This shows that the exercise described in this article is based on previous research, and it is therefore constrained by the outcomes of previous phases of BRAHMATWINN.

It must be said, however, that the IIT must not be thought of as a rigid and definitive table, but more of a flexible structure within which indicators can be added or modified according to research needs and new findings. Ultimately, the crucial feature of the IIT is that it can be a useful tool for the integration of the research results coming from the range of different disciplines represented, combined with the views of LAs.

By creating a relationship between research outcomes (qualitative and quantitative indicators) and LAs' issues and responses, the IIT approach contributes to the implementation of knowledge integration, which many acknowledge as necessary. Thanks to the GAM policy recommendations have been identified. These include improving the level of institutional coordination for the management of water resources, whether in dry or super-abundant periods, the establishment of a legal basis for the comprehensive management of water resources, and the recognition at government level that serious effort, both in planning and policy, is required if Assam is to address current and future availability and potential conflict between the various sectoral user groups. While progress is being made in some key areas (notably in relation to early warning systems), there does seem to be a worryingly low level of effective community participation in decision making.

It has to be noticed that the framework presented in Figure 24 is in fact an iterative cycle. The outcome of the process described in this article, i.e. the definition of recommendations, is presented to LAs and, thus, fed back into the cycle. Whether these recommendations could lead to a decrease in vulnerability, could be monitored using the relevant indicators identified in the IIT (see Giannini et al. 2011). The cycle would in this way be closed, showing one possible method to bridge the gap between science and policy and cope with the impacts of climate change.

This exercise and the proposed methods could be further refined in future studies bearing in mind that the IIT should be developed during the initial phases of the projects and iterative refinements should be allowed for. On the one hand, this would enable researchers to fully address the knowledge demand voiced by LAs; on the other, LAs would have enough time and opportunities to completely integrate local knowledge in the process. The time constraints of the BRAHMATWINN research prevented the partners from rearranging their research agenda in order to meet all the issues expressed by the LAs, and also to acquire all the relevant information from LAs. Nevertheless, partners showed understanding of LAs' needs and willingness to address issues raised by them.

One example of further research that would be needed as a follow up to this exercise is integrating vulnerability indicators into this process. By linking vulnerability indicators or indices in the GAM to governance indicators and response strategies, one could assess the effect of governance measures on vulnerability, by means of future projections of values based on scenarios, or one could also prioritize governance measures to be developed and implemented according to a vulnerability ranking.

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6. CHAPTER 6
EXPLORING SYNERGIES FOR DISASTER RISK REDUCTION IN GUATEMALA: THE USE OF COGNITIVE MAPS

a los Guatemaltecos, les deseo un futuro de Paz

6.1. Introduction

Climate change uncertainties may represent a justification for inaction. To overcome this possibility experiences in coping with risk derived from climate variability could be implemented: these would decrease risk from climate change as well (IPCC 2011; van Aalst 2006). Impacts of climate vary at a local scale, and thus coping measures need to be developed taking into consideration local specificities. Populations which have lived in the same areas for a long time have acquired knowledge which can prove very useful to design coping measures (Allen 2006; O'Brien 2006). There are successful examples in which communities have been able to define and implement plans to cope with climate impacts (van Aalst et al. 2008). To enable this vulnerable communities must not only rely on their traditional knowledge, they must also be empowered and have access to climate information (Zubair 2004).

A possibility to cope with impacts from climate is also given by the integration of two paradigms: CCA and DRR (Schipper and Pelling 2006; O'Brien et al. 2006). A variety of institutions and organizations, with mandate with one or both, are therefore to be involved and the exploitation of synergies among these is necessary. Scientists, policy makers, civil society, practitioners all have their own knowledge and experience, but most lack experience in collaborating with each other (Thomalla et al. 2006). Moreover, they have each their perspective, in relation to the mandate and vision they have.

In this research government organizations (GO), non-government organizations (NGO), and civil society organizations (CSO) that have a mandate or a stake with respect to CCA and DRR are considered stakeholders. Synergies can and should be created among these to improve DRR. GOs, NGOs, and CSOs have different visions, projects, and plans for CCA and DRR. There are differences, but also similarities, among these visions. In the research described in this article an attempt has been made at identifying and analyzing these different visions, and to propose a possible method to reach a shared vision by means of a synthesis, which could enable synergies among different institutions, which have a mandate for DRR.

Ultimately, even if many recognize the need and urgency for collaboration among GOs, NGOs, and CSOs, there are not many examples of models and methods for this. In this research a possible way is explored through the use of cognitive maps (CM), which will be used to assess, compare, and synthesize the different visions.

The chapter is organized as follows. In **Paragraph 6.1.1** the case study outlining the relevance of it with respect to the topic is described. **Paragraph 6.2** is used to describe the method, introducing CM and their use to gather, analyze, and synthesize opinions and visions of stakeholders; also the criteria which guided the creation of the questionnaire designed to draw CM are described. In the paragraph dedicated to results (**Paragraph 6.3**) an overview of possible results is given. The discussion in **Paragraph 6.4** outlines possible uses of the results. Results and discussion paragraphs have mostly methodological relevance as the number of stakeholders who answered the questionnaire is limited, as often happens in research which seldom has the strength to motivate stakeholders in participating. **Paragraph 6.5** concludes indicating further research possibilities and needs.

6.1.1. Case study description

Guatemala is still a very segregated society in which indigenous peoples are marginalized (personal communications). However, Guatemala has signed ILO convention 169 concerning rights of Indigenous and Tribal peoples in independent countries[31]. Some articles are especially interesting and call for the inclusive process I described below:

[31] http://www.ilo.org/ilolex/cgi-lex/convde.pl?C169

Article 6.1:

In applying the provisions of this Convention, governments shall:
(a) consult the peoples concerned, through appropriate procedures and in particular through their representative institutions, whenever consideration is being given to legislative or administrative measures which may affect them directly;
(b) establish means by which these peoples can freely participate, to at least the same extent as other sectors of the population, at all levels of decision-making in elective institutions and administrative and other bodies responsible for policies and programmes which concern them;
(c) establish means for the full development of these peoples' own institutions and initiatives, and in appropriate cases provide the resources necessary for this purpose.

Article 7.3:

Governments shall ensure that, whenever appropriate, studies are carried out, in cooperation with the peoples concerned, to assess the social, spiritual, cultural and environmental impact on them of planned activities. The result of these studies shall be considered as fundamental criteria for the implementation of activities.

Article 8.1:

In applying national laws and regulations to the peoples concerned, due regard shall be had to their customs or customary laws.

In November 2010 I was invited by CARE Nederlands to participate in a series of meetings and workshops taking place in Guatemala, Nicaragua and El Salvador, which had the goal of assessing and eliciting indigenous and local knowledge useful for DRR and CCA. At that time most of the activities were taking place in Guatemala, also the process in this country was in a much more advanced phase than in the other countries I visited, so Guatemala seemed like a good opportunity for me to have a hands-on experience on the implementation of DRR and CCA, which takes as a starting point the need for synergies among GOs, NGOs, and CSOs.

A series of five workshops were facilitated by the Comisión de acompañamiento para la armonizacion de los conocimientos y sabidurías de los pueblos ante la reduccion de riesgo a desastres, hereafter Comisión (see **Paragraph 1.2.2**). All workshops were coordinated by the Coordinadora Nacional Reduccion de Desastre (CONRED) and facilitated together with delegates of the National Council of CONRED (Ministry of Education, Ministry of Environment, Ministry of Agriculture, and Secretariat for Food Security). Two workshops were attended by representatives of the Maya communities, the largest group of native people communities in Guatemala, and one by representatives of the Xinca community. The fourth workshop was attended by representatives of the Garifuna community and took place in Livingston on 11 and 12 November 2010. The fifth, and last workshop, took place in Guatemala City on 30 November 2010, with representatives from all three peoples, Maya, Xinca, and Garifuna, selected in the previous workshops. During the first four workshops participants, who were selected because of their knowledge and prominent role in their communities, shared their vision and knowledge, which was recorded by members of the Comisión. After presentations from members of the Comisión, which framed the goal of the process and gave a first overview of findings in previous workshops, questions were asked to guide the collection of information, and small groups were formed to work on identifying traditional and local knowledge and address issues of risk reduction and emergency. The fifth workshop was organized to enable knowledge exchange among all three peoples, and to facilitate identification of commonalities as a first step in a longer process of inclusion of peoples' vision into DRR and CCA at the national level. This first phase ended on 1 December 2010 with the signing of the institutionalization of the Comisión in the National Palace in Guatemala City by the President Álvaro Colom Caballeros, the Deputy President José Rafael Espada, the Director of CONRED Alejandro Maldonado, and Don Alejandro Cirilo Pérez Oxlaj representative of the peoples.

I had the privilege of being invited to the fourth and fifth workshops, and to the signing of the institutionalization of the Comisión, along with a series of preparatory meetings during which organization and issues were discussed. During my stay I also had the opportunity of interviewing several people involved in this process, both integrating the Comisión and/or belonging to NGOs and CSOs. These people are the core of stakeholders I have interacted with during my research. They shared with me their knowledge and expertise in working in a multicultural setting, facilitating inclusive processes, and empowering peoples whose voices are not usually heard.

The workshop held in Livingston started with presentations to introduce the project and to define the objectives of the workshop. Afterwards four groups were formed to work on the following questions:

1. What story can you tell about disasters happened previously?
2. Do dreams have a meaning?
3. What do animals do before a natural event?
4. What is the relationship between the Garifuna spirituality and natural events?
5. How can we live with mother nature, water, earth, air, forest an fire?

On the second day of the workshop the plenary discussion addressed the same questions, and then each group representative presented the results of the previous day. Two representatives from each group were selected to participate in the national workshop which was held in Guatemala City (30 November 2010).

The workshop ended with a discussion on further steps of the process and the participation to the national workshop, including a Garifuna ceremony. The Garifuna asked to be informed about results, too often it has happened that researchers come, elicit knowledge from the community, and never return results and outcomes. Also, policies and plans can be implemented only if they are developed within a participatory process; otherwise they fail to address the goal. Communities want to have a say and be involved in the decision making process.

Culmination of this first phase was the national workshop held in Guatemala City on 30 November 2010. Representative from each of the four workshops held were invited to exchange their cosmovisión with the other communities. A joint ceremony was held to open the workshop: spiritual guides for Maya, Xinca and Garifuna celebrated it. 52 people participated, 41 of which were community representatives. After a summary of activities and findings, discussion began on the way forward. The objective was agreed upon: signing of an agreement to institutionalize the Comisión, which will continue its work of collection and systematization of indigenous and local knowledge. CONRED representatives compromised themselves to bring this process forward as much as is allowed by their mandate, in the hope that together little step by little step they will be able to change this country. The process started earlier in 2010 had a very necessary moment on 1 December 2010, when the President and Deputy President of the Republic of Guatemala signed the institutionalization of the Comisión in the National Palace.

6.2. Method

The unique opportunity offered to me by CARE Nederlands while searching for a case study to gain insight and understanding of on-the-ground work in CCA and DRR seemed to be very fitting for my research. To exploit it properly I started searching methods and tools appropriate for the acquisition of information on visions, opinions, and knowledge on CCA and DRR, i.e. stakeholders' mental models. The method and tool I was looking for had to satisfy two fundamental criteria: (1) enable organization of information, (2) allow comparison among different visions. Soon my attention focused on possibilities offered by cognitive maps. Searching Web of Science with the key words <cognitive map> 6007 articles are found, spanning over 100 disciplinary sectors, testifying the wide use of this tool. On the contrary, adding in the key words either <disaster risk reduction> or <climate change adaptation>, or both, no results are found, possibly implying no articles have been published describing such application. Literature was found on the use of cognitive maps for natural resources management.

The research described in this article is used to test the methodology proposed, and results are found to have some meaning. However, the research must be based upon a wider stakeholder base, thus the effort to contact the stakeholders who have not yet compiled the questionnaire is ongoing. Opportunities to meet a selected number of stakeholders in person are being sought, and, at the same time, contact by email and telephone is also carried on.

A CM is a graphical representation where concepts and opinions are represented by nodes, and causal relations between nodes are represented by a link, the term "cognitive map" was first used by Tolman in 1948 (Özesmi and Özesmi 2003). The definition of mental models by means of cognitive maps enables confrontation of stakeholders with different opinions: cognitive maps are useful tools to gain insights on stakeholders' visions; however, eliciting them can still be a challenge (Jones et al. 2011). A very detailed history of cognitive maps, where many uses are described, can be found in Özesmi and Özesmi (2004).

My first idea was to draw CM during face to face interviews while in Guatemala during my stay of November 2010. For this I started designing a questionnaire, which should have guided stakeholders to draw the CMs themselves. This first attempt was not successful: after five interviews I understood not all stakeholders are comfortable in drawing CMs, and therefore I decided to develop further the questionnaire and use it to elicit information and later derive myself CM, as suggested by Özesmi and Özesmi (2004).

Therefore a questionnaire was designed to gather information from each single stakeholder to be able to draw his/her specific CM, which will represent each stakeholder's idea with respect to the identification of risks and hazards, and the definition of DRR. The CMs will establish relationships between different impacts, which are caused by climate variability and change. Through the use of matrices natural hazards and anthropogenic disasters will be connected to risks. Key for this is to acquire information about when hazards generate risks. The identification of possible risks will then enable the definition of response measures needed to monitor and/or reduce risk. The terminology used for the questionnaire is coherent with that of UNISDR, made available both in English[32] and in Spanish[33] on their website.

The questionnaire was divided into two parts: the first to understand what stakeholders think about risk, and the second to understand what stakeholders think about DRR. Some of the questions were open ended, to allow for free expression of stakeholders, and to make sure all relevant information was collected; other questions were multiple choice, to allow for comparison among answers, and to facilitate stakeholders' answers. Questions and answers were defined keeping in mind a matrix would be needed to draw the CM.

A review of websites on DRR, such as UN-ISDR, was carried out to define questions, to acquire definitions, a glossary was, in fact, taken from UN-ISDR, and to identify risks, hazards, and DRR measures, i.e. all the multiple answers available. The first draft of the questionnaire was in English, but the definitive one was written in Spanish. The questionnaire was tested with the help of native Spanish speakers who work in the field of CCA. Then, using the web platform Qualtrics[34], the questionnaire was made available to stakeholders online.

CMs are then drawn with the information derived from the questionnaire using FCMapper[35] and Pajek[36], both freely available on the internet. FCMapper is an excel spreadsheet, which enables analysis of cognitive maps by means of algorithms defined to calculate descriptive variables of cognitive maps according to fuzzy logic. Only some elements of FCM are used for the analysis in this research. According to Özesmi and Özesmi (2004), in fact, several kinds of analyses can be performed. Considering <N> the number of nodes (parameters, variables or concepts), and <C> the number of connections (edges or links) the following analysis will be performed:

a. MOST MENTIONED NODE: ideally the most recurring node should identify the most important concept expressed, so by counting how many times a node is present in all the maps a ranking could be made (Özesmi and Özesmi 2004:50)

b. DENSITY: this index <D> shows how connected or not each FCM is, a FCM with a high D corresponds to a stakeholders who is able to identify many causal chains: a "catalyst of change" (Özesmi and Özesmi 2004:50)

$$D = \frac{C}{N(N-1)}$$

c. OUTDEGREE (od) and INDEGREE (id): these are the row (od) or column (id) sum of absolute values of a variable (v_i) in the adjacency matrix (a_{ij}) (Özesmi and Özesmi 2004:51)

$$od(v_i) = \sum_{k=1}^{N} a_{ik} \qquad\qquad id(v_i) = \sum_{k=1}^{N} a_{ki}$$

transmitter variables have $od(v_i)>0$ & $id(v_i)=0$

receiver variable have $id(v_i)>0$ & $od(v_i)=0$

ordinary variables have $id(v_i)\neq 0$ & $od(v_i)\neq 0$

[32] http://www.unisdr.org/we/inform/terminology
[33] http://unisdr.org/files/7817_UNISDRTerminologySpanish.pdf
[34] http://www.qualtrics.com
[35] http://www.fcmappers.net/joomla/
[36] http://pajek.imfm.si/doku.php?id=pajek

d. CENTRALITY (c): is the sum of outdegree and indegree, *it shows how connected a variable* (node) *is to other variables* (nodes) *and what the cumulative strengths of these connections are* (Özesmi and Özesmi 2004:51)

$$c_i = od(v_i) + id(v_i)$$

FCMapper also creates a net file which can be read by the freeware Pajek, which creates the cognitive map. Several visualization possibilities are offered by Pajek, and also analyses can be carried out.

Moreover, FCMs drawn from information collected from stakeholders can be combined by adding adjacency matrices. The resulting matrix can again be transformed into a FCM (Kosko 1988; Taber 1991; U. Ozesmi & S. L. Ozesmi 2004). To combine FCM first an augmented matrix has to be created by listing all nodes in rows (and in columns) then each matrix is coded into the augmented matrix, and finally all matrices are added (Özesmi and Özesmi 2004). Following Özesmi and Özesmi (2004) a weight could be assigned to each FCM if there are reasons to give more value to one stakeholder over another: in this case we value all information equally. The goal of combining all matrices is, in fact, that of a possible method to integrate all stakeholders' opinions.

Having defined the goal of the research, criteria for stakeholder selection were defined. As said before, GOs, NGOs and CSOs with a mandate, or stake, in CCA and DRR were selected. Moreover, two levels of stakeholders were identified as relevant: international and Guatemalan.

For the international regional level I selected organizations through the PreventionWeb[37] database using the two sets of conditions listed below. PreventionWeb is a project of UNISDR launched in 2007 to support knowledge exchange within the DRR community.

- hazard: any; theme: disaster risk management, region: Americas; country: any (refined by hand considering only those that have mandate for Guatemala); org type: un & international organizations
- hazard: any; theme: disaster risk management; region: Americas; country: Guatemala; org type: regional intergovernmental

For the national and local level I selected people from GOs, NGOs, and CSOs from my personal list, which includes:

- the Guatemalan "Comisión de Armonización de los Conocimientos y Sabidurías de los Pueblos Maya, Xinka, Garifuna y Mestizo, ante la Reducción del Riesgo a los Desastres"; these are key informants from the following entities: indigenous and local peoples representatives, national and local government officials, and disaster risk management authorities
- stakeholders involved by the Comisión in their process (roughly 100 stakeholders)
- NGOs which integrate the consortium "Partners for Resilience"[38] (project funded by the Dutch Ministry of Foreign Affairs).

6.3. Results

A first run of the questionnaire was carried out only with the Guatemalan stakeholders: over 100 stakeholders were contacted by email. Unfortunately, after many attempts, only twelve compiled the questionnaire, of these only eight questionnaires were complete: this is about the expected response rate for web surveys, which is 6-15% according to a meta-analysis published recently (Manfreda et al. 2008).

Answers from questionnaires were elaborated with a spreadsheet (open access) to create the matrix, and to homogenize similar concepts expressed, trying to keep as much richness as possible. The matrix was then imported in FCMapper, analysed and then a net file was created and imported in Pajek. This was repeated for each SH, and then a total matrix summing all SHs' matrices was created. Results described here validate the method adopted, and give some initial insights. However, more SH would be needed in order for results to be definitive.

The first variable analysed is MOST MENTIONED NODE. Looking at the separate categories (natural hazards, targets, human causes for risk increase, institutions, DRR measures) no node seems to prevail in any category. This can be seen as a validation of the questionnaire: it means, in fact, that all nodes identified have some importance for stakeholders.

[37] http://www.preventionweb.net/english/professional/contacts/
[38] http://www.climatecentre.org/site/partners-for-resilience

The variable CENTRALITY, on the contrary, gives some promising results. First of all in Figure 27 one can identify which natural hazards are the most relevant for the region: flood and mudslides. This is consistent with the data presented in the introduction. The other natural hazards are more ore less all equally relevant, besides tornadoes, which has been selected only by three out of eight SH. Even if given the possibility of adding other not mentioned hazards related to change, stakeholders did not add any.

Risk is not composed only of natural hazards: there are also anthropogenic causes which make risk increase (Figure 33 **in annex**). Poverty is far more important than the others: about twice as important with respect to the rest. Linking this with the above, and to the general context of Guatemala, one could argue that poverty is what causes people to live in risk prone areas. While this is not a surprise, there is a surprise in the apparent lack of a direct link between, for example, <building on marginal lands> and both <flood> and <mudslide>. A consequence of poverty is generally though to build and live in risk prone areas, but none of the ones listed in the multiple answers are nearly as important as poverty. The stakeholders, given the possibility, added other human causes for risk increase, such as soil degradation, building without risk assessment, and illegal land-fills.

Going to the section on DRR measures (Figure 34 **in annex**) the first issue to note is that the most important measures seem to be those related to general themes, such as <public awareness>, and to all those measures relative to institutions, such as <institutional plans and regulations> and <map risk and no build areas>. Measures represented by interventions at a smaller localised scale, such as <river banks reforestation> are evaluated as less relevant.

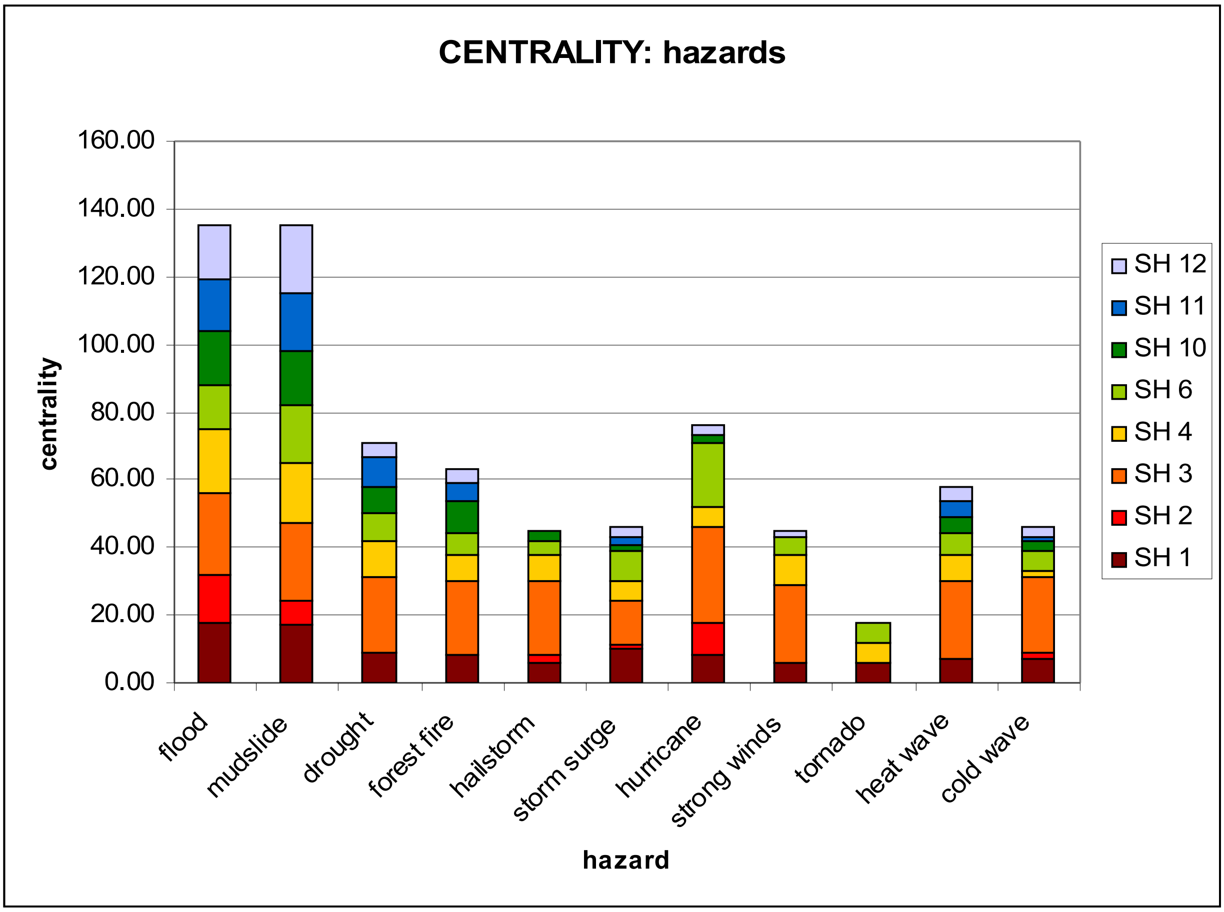

Figure 27. centrality: hazards (elaboration made with FCMapper)

Stakeholders were also given the possibility of adding other existing or needed DRR measures. The result is a long list of over 40 measures regarding: capacity building, information, education, need for laws and policy, improvement of synergies and cooperation, engineering solutions, availability of tools and resources for emergency response, inclusion of local and traditional knowledge, implementation of prevention plans and projects.

The following chart (Figure 35 **in annex**) seems to contradict the prominent role of CONRED, but the role of CONRED is only slightly smaller than that of all NGOs taken together, so one could argue that CONRED is in fact the most important institution. As one would have thought <CONRED>, and <other public authority> if summed are at the top of the rank for centrality within institutions for the role they have in DRR. It must also be noted that <NGO> have a slightly higher importance mainly due to one answer, that of SH 3. This also shows that with such a limited number of stakeholders' answers one opinion gains too much importance and possibly introduces a bias and skews results.

Generally speaking, besides the already mentioned anomaly expressed by SH 3 with respect to the prominent role of NGOs, all SH seem to agree: relative rankings of centrality for all four variables (hazards, causes for risk increase, DRR measures, institutions) are quite the same.

Not all questions and answers can be analysed and described with this same method. Emergency measures in fact are elicited according to the different hazard and are open ended questions. The result is a list of over 20 measures, which relate to the need for information, both on how to identify warning signals, and on what to do (e.g. go to a shelter or safe place), along with other specific actions to be undertaken (e.g. drink water or fight fire), and more holistic approaches, such as the need for zoning laws, for informing communities on climate change, and for a general awareness on environmental issues.

Then net files were created with FCMapper and opened with Pajek to create cognitive maps (Figure 28 **and figures in annex**). A first look at all the maps, one for each stakeholder, reflects the complexity and interconnection of the issue of DRR. Many are the hazards and risks identified, thus, there are links amongst these nodes. Moreover, there are multiple measures identified and linked to these. However, more interesting is the cumulative map made summing all matrices. First a matrix is created with all nodes identified listed both in rows and columns, and then each matrix is made coherent with this structure. The matrices are summed and normalised dividing each cell by eight (as this is the number of SHs who completed the questionnaire).

The first attempt to create one total cognitive map (TCM) integrating all single CM is shown in Figure 29. A first look at the TCM clarifies the complexity of considering all risks at once, since Guatemala was chosen because globally it ranks high considering multiple risks this is no surprise (see Figure 1). Nevertheless, the TCM can be useful to understand several issues:

- first of all roles for institutions and organizations (grey circles) have with respect to DRR measures (yellow squares); also, orange diamonds indicate what mandates they have during an emergency;
- risks are identified by blue diamonds. The nodes linked only to risks are those which have been added by SH (bottom left of TCM). Risks on the right hand side of the node <RISK> are those which have been provided in the multiple choice answers, and are linked to the natural hazard they may increase;
- specific measures to address each risk are also identified (orange diamonds on right of TCM), and which of these should be used to address impacts of each hazard;
- DRR measures (yellow squares) are divided in common ones, connected to the specific natural hazard, and ones suggested by stakeholders, connected to the type of institution to which the stakeholder who suggested them belongs.

Table 15. legend for all CM

red triangle	hazard
blue diamond	causes for risk increase
orange diamond	what to do during an emergency
gray circles	GO, NGO, CSO
black box	risk and DRR
yellow box	DRR measures
green circle	both cause for risk increase and DRR measure

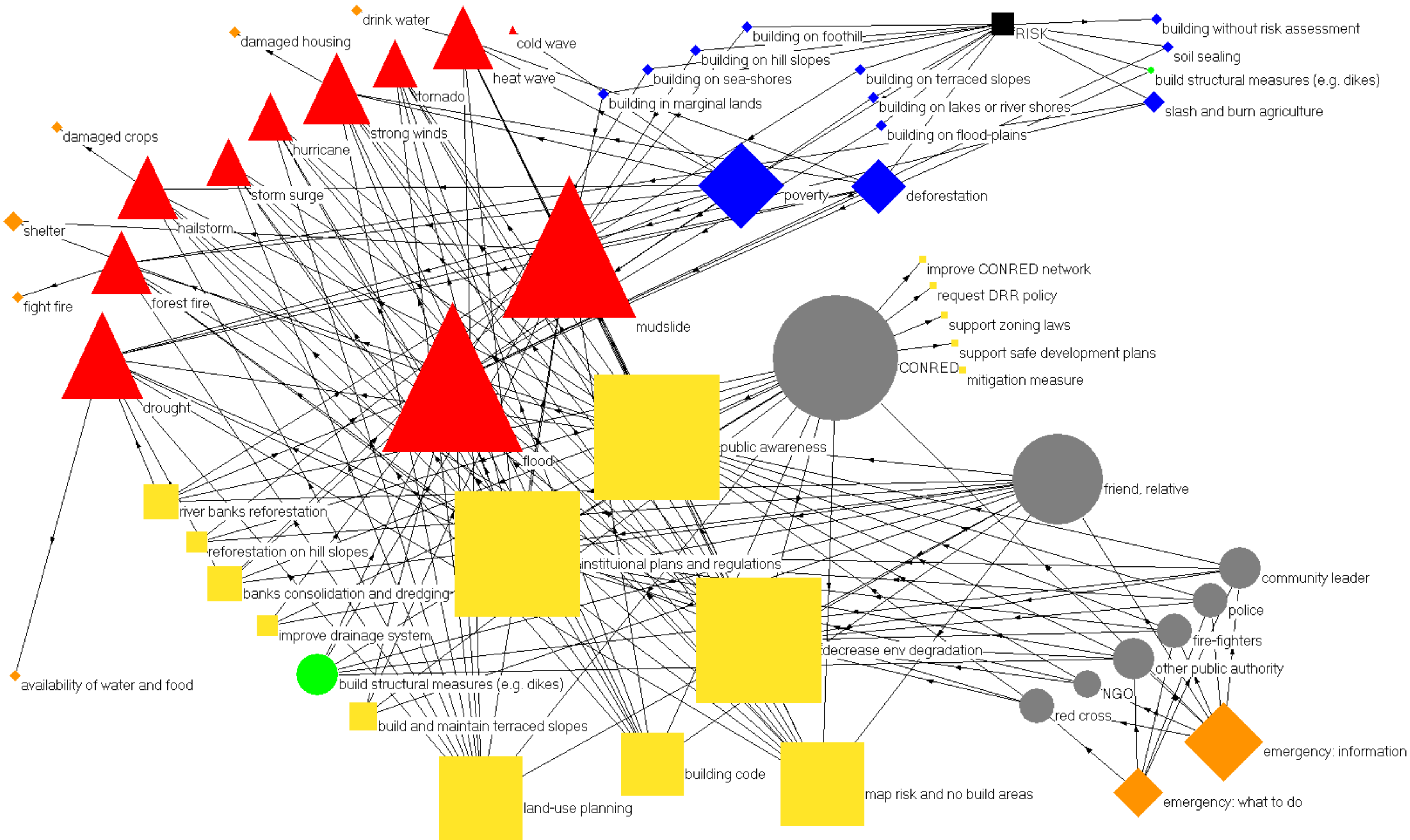

Figure 28. cognitive map (SH 4), dimension of nodes represents centrality elaboration of questionnaires made with FCMapper and Pajek.

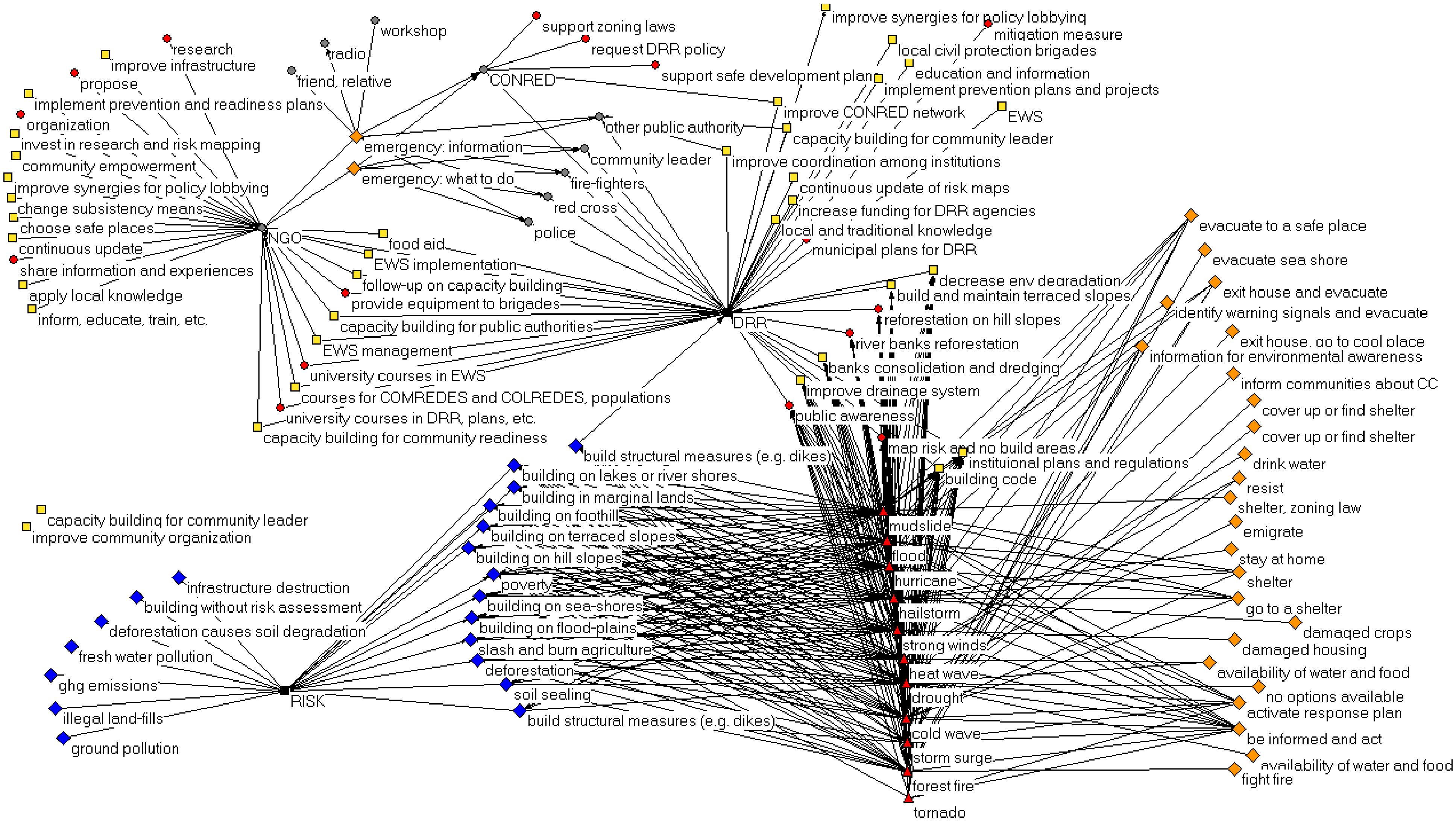

Figure 29. total cognitive map,
elaboration of questionnaires made with FCMapper and Pajek

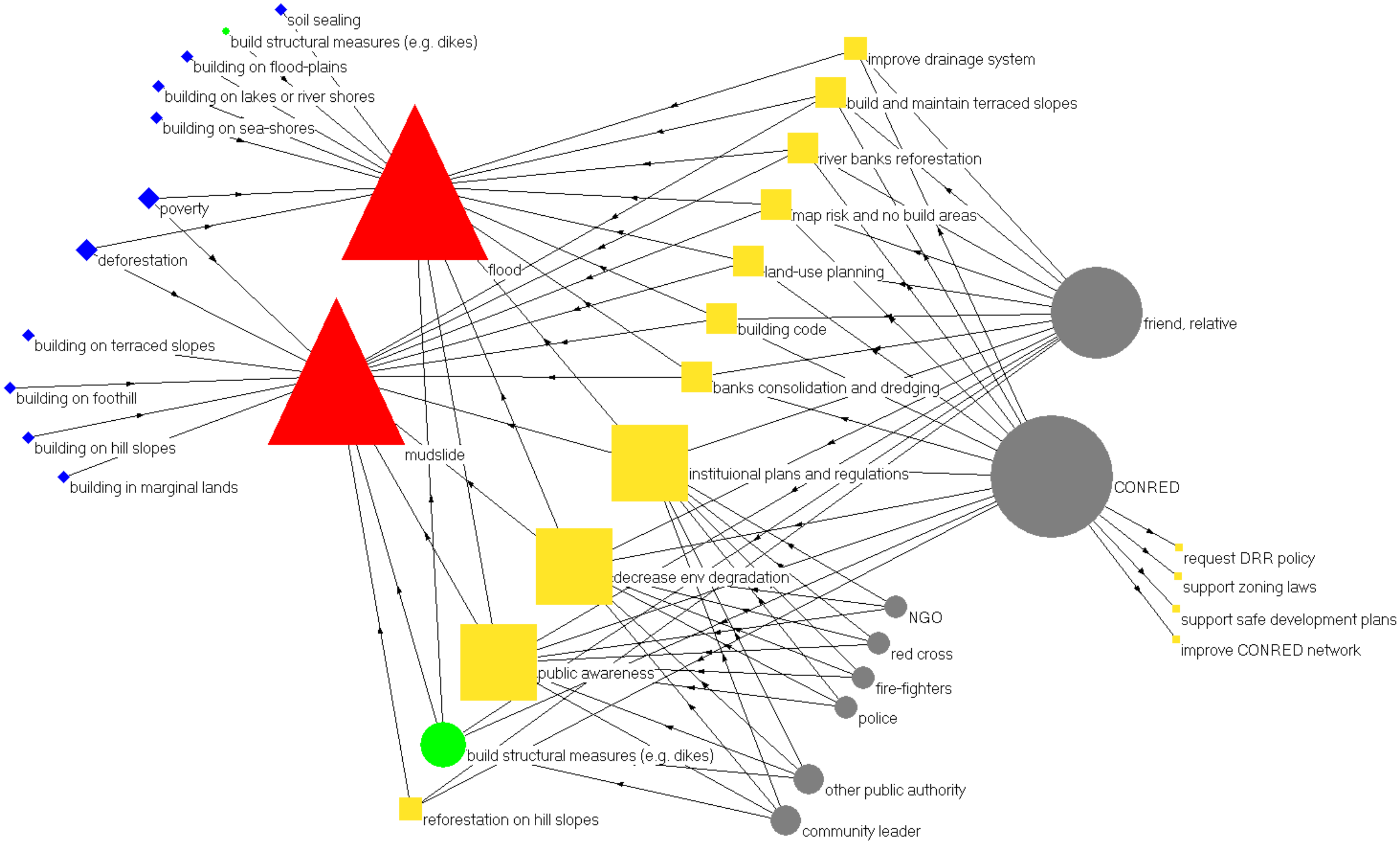

Figure 30. cognitive map drawn considering only nodes directly linked to FLOOD and MUDSLIDE (SH 4), dimension of nodes represents centrality, elaboration of questionnaires made with FCMapper and Pajek.

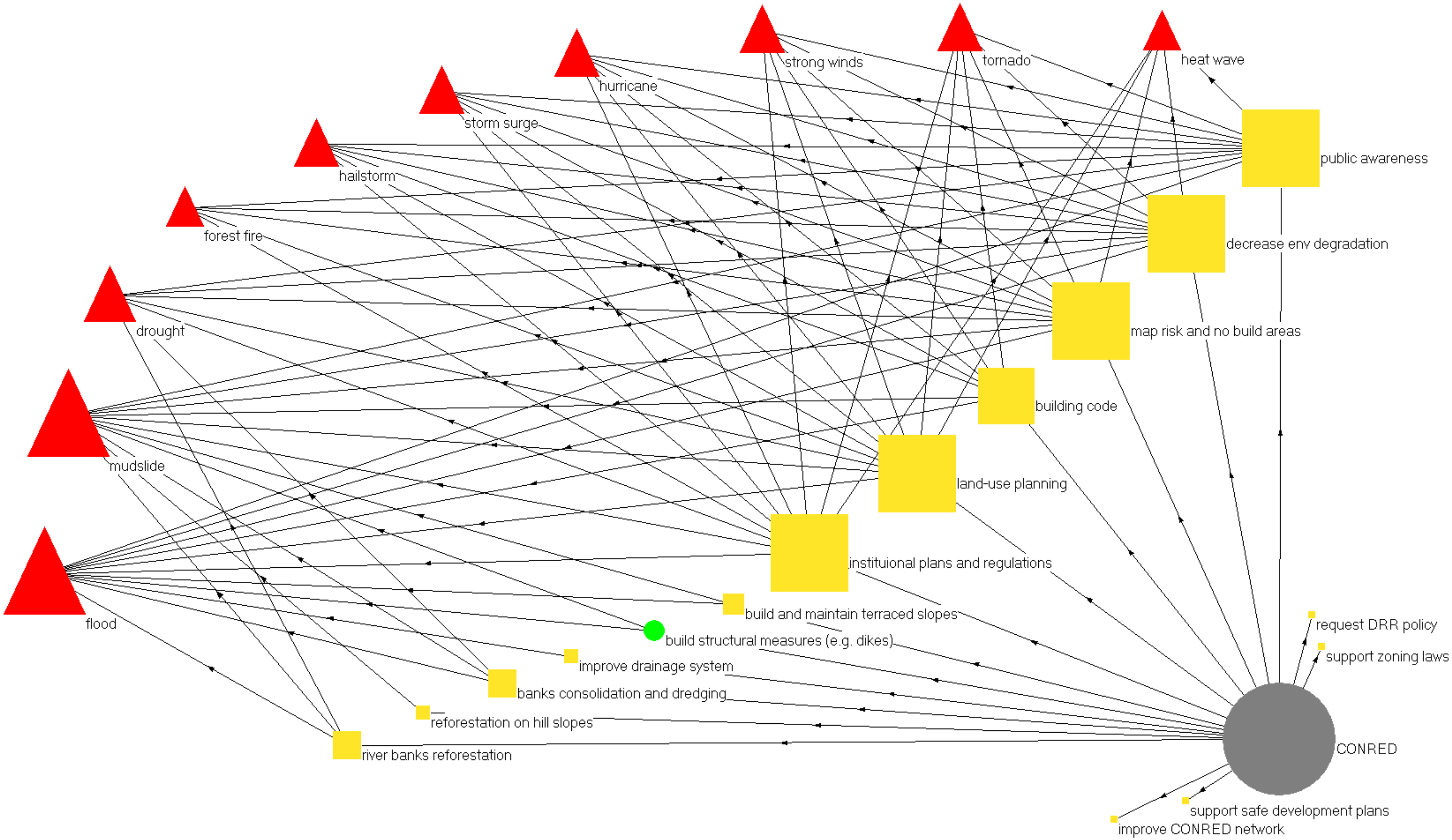

Figure 31. cognitive map drawn considering all hazards and only one institution CONRED (SH 4), dimension of nodes represents centrality, elaboration of questionnaires made with FCMapper and Pajek

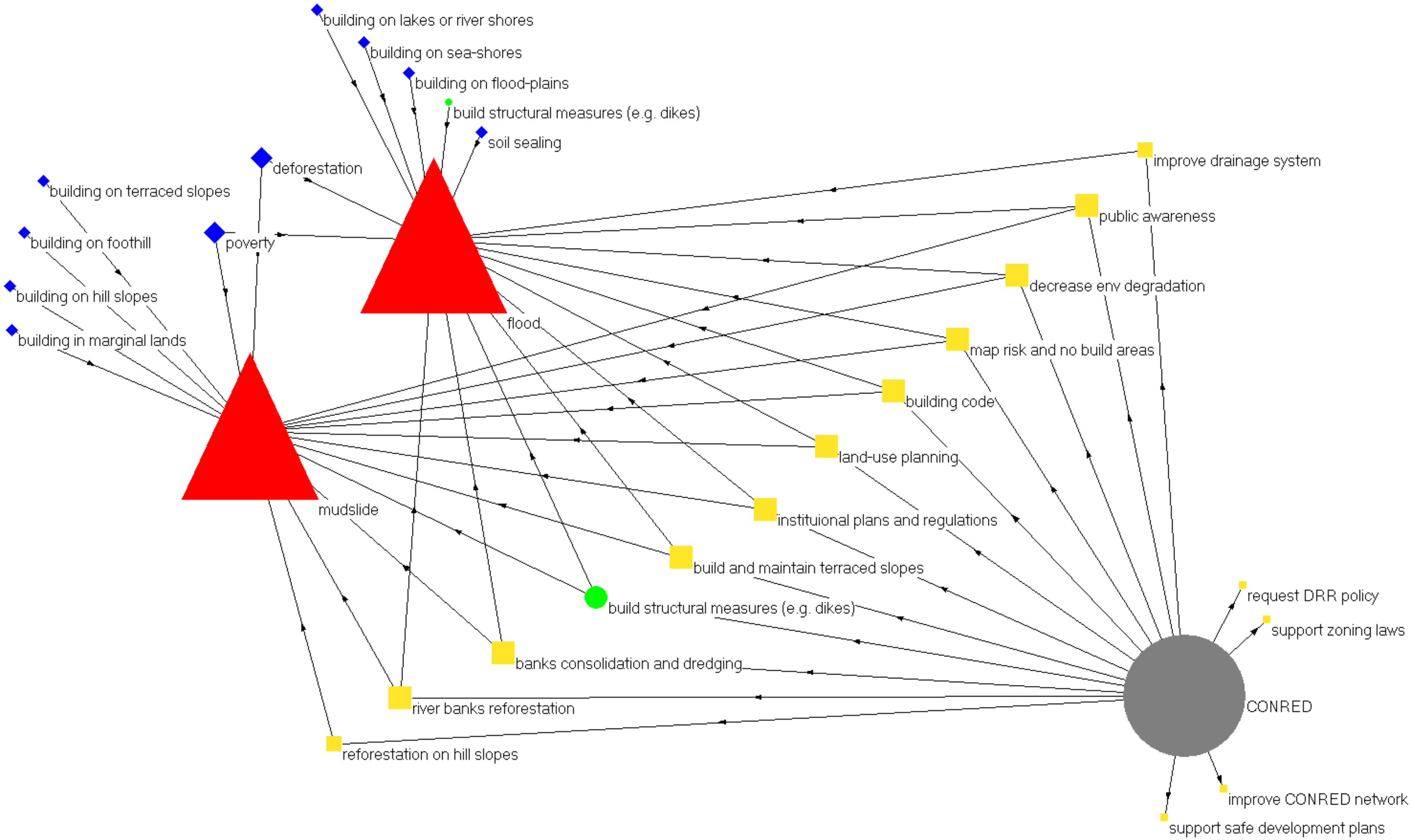

Figure 32. cognitive map drawn considering nodes directly linked to FLOOD and MUDSLIDE and only one institution CONRED (SH 4), dimension of nodes represents centrality, elaboration of questionnaires made with FCMapper and Pajek

Considering one hazard, or linked hazards as is the case drawn in Figure 30, and one stakeholder we can decrease complexity while retaining meaningful information, and obtain CMs with some usefulness. For instance a CM can be used to identify possible DRR measures needed to cope with one specific hazard, or linked hazards. One should start by selecting hazards to cope with, and from these hazards draw one specific cognitive map, selecting only those nodes connected to the hazards. For instance if we select the hazards <flood> and <mudslide> and delete from a CM all nodes not linked to these, we can draw the CM shown in Figure 30. The resulting CM will show what could make risk increase with respect to flood and mudslide (blue diamonds), what DRR measures are needed to cope with these hazards (yellow squares), who is in charge of implementing these DRR measures (grey circles), and other DRR measures suggested by SH4 (yellow squares).

Another specific CM can be drawn if one considers all hazards, and only one institution among those who have a mandate in DRR, see Figure 31. From this CM one could understand what plans can be implemented by the specific institution to cope with all the hazards. Finally, a CM can be drawn with both the restricting conditions described above: one set of hazards (e.g. flood and mudslide) and one institution (e.g. CONRED), see Figure 32. This CM shows the specific DRR measures that should be implemented by the selected institution to deal with identified hazard.

6.4. Discussion

This CM exercise proves that it is possible to develop CM to define concepts of risk and DRR from an online questionnaire. Comparing this result to a previous attempt made in face to face interviews within the same research, proves that this was a preferable way for this case study: it was easier to have SH answer questions, rather than have them draw a CM themselves. The questionnaire should be structured keeping in mind that for the CM to be created the final result should be a matrix, thus, multiple choice questions in a matrix form are well suited for this, too many open ended questions, in fact, make the number of rows and columns in each matrix increase and make comparability difficult. However, also some possibility to add missing concepts should be given, and then these could be integrated in an ad hoc matrix.

The variables calculated by means of FCM algorithms have proven to be well suited to understand relative importance of nodes considered, i.e. natural hazards, anthropogenic causes for risk increase, institutional roles, and DRR measures. Outcomes show that the role of CONRED is central, as should be according to the law, which prescribes that CONRED should coordinate actions of local civil institutions, such as police, fire fighters, and red cross; nevertheless, NGOs and other institutions also have a high centrality.

Looking at natural hazards one can note the higher relevance of floods and mudslides, which is coherent with the country profile described in the literature. The other hazards are probably less important because specific to some parts of the country and not general like the first two.

Similar interpretation can also be valid for human causes for risk increase. Poverty is certainly one of the most relevant issues in Guatemala, as according to the human poverty index it is ranked 131 out of 187[39]. The other causes are frequent in specific places, so they do not have the same national relevance, such is the case of building on sea, lake and river shores, on slopes, and on foothill. Moreover, country analysis and direct interviews identify deforestation as one of the most relevant anthropogenic disturbances, however, this is a problem which is often overlooked (G.Paiz and people from the Comisión).

Analysing results of centrality for DRR measures, three groups can be found. The first is constituted of <institutional plans and regulations> and <public awareness>, these are very general measures. Also all the ones in the second group of importance are very general: <decrease environmental degradation>, <map risk and no build areas>, <building code>, <land-use planning> (in decreasing order of importance). The second group relates to the need of stronger institutions, which relates back to the most importantly ranked <institutional plans and regulations>. The third group is made of specific and local interventions, such as <reforestation on hill slopes> and <river banks reforestation>.

Reading the list of DRR measures added by SH one can note the importance of knowledge, its dissemination and integration, and capacity building. There is a request for local knowledge integration in the decision making process and for empowerment of local communities which is expected given the SH choice described in **Paragraph 6.1.1**.

The single SH's cognitive maps and the total cognitive map identify a possible method for the definition of risk and identification of DRR measures. Analysing the TCM one notes the high number

[39] http://hdr.undp.org/en/statistics/

of DRR measures linked to the NGO node, as compared to the ones linked to the other ones (25). CONRED with 16 ranks second in this list. However, the ones linked to CONRED are much more general in scope, and, possibly, more effective with respect to general DRR, while those linked to NGOs could prove more effective in specific locations. The other institutions and organizations mentioned are less relevant, thus there is still room for improvement by increasing their agency.

Finally, selecting only specific nodes from the TCM, e.g. one hazard at a time, or a combination of one hazard and multiple institutions, one could understand what needs to be done to decrease a specific risk derived from the hazard, and by whom. In this selection process possible synergies can be enabled: knowing the mandates and roles, and identifying the link with the relevant institutions the creation of synergies can be fostered.

6.5. Conclusion

Some goals of this research so far have been met: a possibility for the improvement of the interactions among GOs, NGOs, and CSOs for DRR is feasible. For this to happen the TCM is a valuable tool, useful for the identification of the issues, e.g. hazards and risks which are the nodes of the TCM, and links, which represent the interactions among these. The TCM is also valuable to define roles and responsibilities of GOs, NGOs, and CSOs to improve DRR.

Building on synergies between these communities CM can be created based on each SHs knowledge and understanding. Then all CMs can be integrated to create a shared understanding, i.e. a TCM, which includes all information elicited from single stakeholders. Lessons can be learned from the experience of each to overcome miscomprehensions and problems.

Stakeholders from participating might gain:

- enable identification and exploitation of synergies among them;
- government organization (GO): by integrating CSOs since the knowledge acquisition phase the implementation process of DRR will be improved; GOs, including local administrations that have mandate for DRR at the lowest level according to subsidiarity principle, could develop a similar framework and establish a participatory and inclusive process;
- non-government organization (NGO): acquire a role in the decision making process as catalysts for improvement and holders of knowledge; improve their understanding of what their role can be in DRR, including what responsibilities they can assume;
- civil society organization (CSO): often not taken into consideration as they should be, they could in this way make their voices heard and influence the decision making process by providing information/knowledge, they ask for institutional support and collaboration (ILO convention 169 on Indigenous Peoples' rights).

The potential with respect to DRR of each single vision, and/or of the synthesis vision defined in the TCM, could be explored using the links established in the CM. The TCM or the single SH CM could, in fact, be used to monitor effectiveness of DRR measures looking at the implementation of identified and designed plans and projects (i.e. those identified in the nodes of the CM, yellow squares), and the effect these have on risk (i.e. considering the nodes where possible causes for risk increase are listed, blue diamonds) and having established links with natural hazards (i.e. relative nodes, red triangles).

The outcomes of this research should be shared and validated with all the stakeholders who participated in the design of CMs. Stakeholders will be presented with the results and will be asked to assess them with respect to their knowledge and expectations.

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I would like to take this opportunity to thank Carlo Giupponi for encouraging me to follow my thoughts; researchers at IVM of Vrije Universiteit in Amsterdam where I started developing ideas which led to this research; Care Nederlands for funding my travel to Guatemala, especially Tialda and Andres for the support in Guatemala; members of Comisión for welcoming me in their activities and meetings; and all stakeholders who have participated in research by providing insights and sharing their knowledge.

RESEARCH CONCLUSIONS

Approaches have been developed and tested to operationalize CCA, integrating two most common paradigms, namely IWRM and DRR. Opportunities have been sought and created through the involvement in a research project, BRAHMATWINN, and in a participatory process, run by CARE Nederlands in Guatemala called "La cosmovisión de los pueblos de la humanidad en la construcción social del conocimiento para la RRD y ACC" (The vision of peoples for the social construction of knowledge for DRR and CCA).

Three tools have been developed to integrate, analyse, and synthesize knowledge, to operationalize paradigms and frameworks: the IIT, the GAM, and the TCM. Knowledge was elicited from stakeholders, analysed, and systematized with the help of spreadsheets, decision support systems (mDSS), and cognitive maps (FCMapper and Pajek). Results were shared with all who participated in the research by contributing knowledge. The positive evaluation given by stakeholders involved represents a first positive outcome of the research, and it sets the basis for the further research phases. Knowledge acquisition and dissemination are, in fact, necessary to provide all involved stakeholders with a shared understanding of the system, enabling the possibility of interaction.

In this research it is shown that both IWRM and DRR can be, and should be, integrated in CCA to increase effectiveness and, thus, decrease impacts of climate on the SES. Each of the three paradigms has its own specific sector of reference; however, in a holistic management perspective considering the SES, ways to integrate them as much as possible have been sought. Ultimately the result has been that of developing or identifying measures to cope with one impact of climate: flood risk.

The opportunity offered by the research project BRAHMATWINN enabled knowledge integration among researchers of the project consortium, which is not always easy to achieve. It also enabled addressing issues raised by LAs, creating the possibility to have research results which meet information demand and needs of end-users, e.g. local administrators.

Within this context two possible uses for the research outcomes have been explored. The first is that of evaluating the effectiveness of responses (using the DPSIR terminology) to cope with flood risk under the impact of climate change. This evaluation is carried out by means of the freeware mDSS, which uses MCA, and thus enables use of different criteria in the assessment. The evaluation was carried out in a qualitative way; however, mDSS offers capabilities of quantitative assessments as well, provided that qualitative outputs of models are available. This could be explored in further research, analysing effectiveness of responses according to scenarios of climate change.

The second use of research outcomes was the identification of gaps in the IWRM governance framework of the State of Assam (India). A method was developed to integrate results coming from different disciplines, namely a matrix was created using the information relative to governance collected and organized in the IIT. The information was then arranged in matrix format and qualitative scores given for the assessment of the existing governance. This enabled "quantification" of how well existing laws, and their implementation, match expectations of LAs.

Finally the research in Guatemala offered the opportunity of analysing and identifying ways to foster synergies among actors with a mandate on DRR, representative of three sectors, namely GO, NGO, and CSO. The inclusive process developed in Guatemala to harmonize knowledge offered the possibility to interact with stakeholders. The three sectors agreed to share their knowledge and experience answering to an online questionnaire. With the information gathered through the questionnaire with the aid of freewares (FCMapper and Pajek) cognitive maps were created representing each one stakeholder's mental map. More interestingly all the information gathered was summed to create one comprehensive matrix and the relative cognitive map, called here TCM. Setting criteria several kinds of cognitive maps can be created from this TCM using sub-sets of the rows and columns of the matrix. Examples are shown, which demonstrate the possibility of using the information collected to understand what to do in case one hazard, or more, happens, or what roles and mandates GOs, NGOs, or CSOs have.

In sum the success of this research is due to the identification, organization and/or creation of relevant knowledge, which enables a shared understanding of the system. In doing so expectations of local stakeholders involved were met by including their visions and opinions in a decision making process. This research was guided by the need for developing methodologies based on hands-on experiences;

however, this research not only developed methodologies, but also tested them producing results of some significance. Stakeholders who participated in the research, in fact, expressed satisfaction that their opinions and visions have been included in the outcomes. The positive judgement expressed by stakeholders on the possibility of using the designed methods might mean that they will in the future implement these methodologies themselves; at least this is what they at times stated.

LIST OF PUBLICATIONS

	Ceccato, L., Giannini,V., and Giupponi, C. (2011) Participatory assessment of adaptation strategies to flood risk in the Upper Brahmaputra and Danube river basins. Environmental Science and Policy 14(8):1163-1174 doi:10.1016/j.envsci.2011.05.016 my contribution: definition of the framework for the evaluation of the responses, management of the case study, organization and facilitation of workshops, parts of discussion and conclusions.
	Giannini, V., and Giupponi, C. (2011) Improving water governance through science and stakeholder dialogue: experience from Assam (Northeast India). CMCC Research papers RP0115. http://www.cmcc.it/pubblicazioni/pubblicazioni/research-papers/rp0115-cip-12-2011 my contribution: design of the framework for the gap analysis: knowledge flow and integrated indicator table, parts of discussion and conclusions.
	Giannini, V. and Giupponi, C. (2011) Integration by identification of indicators, Adv. Sci. Res., 7, 55-60, doi:10.5194/asr-7-55-2011. my contribution: core contribution to the BRAHMATWINN research project: this research was carried out under direct supervision and in coordination with Carlo Giupponi
	Giannini, V., Ceccato, L., Hutton, C., Allan, A.A., Kienberger, S., Flügel, W.-A., and Giupponi, C. (2011) Development of responses based on IPCC and "what-if?" IWRM scenarios, Adv. Sci. Res., 7, 71-81, doi:10.5194/asr-7-71-2011. my contribution: definition of the framework for the evaluation of the responses, management of the case study, organization and facilitation of workshops, parts of discussion and conclusions.
	Giannini, V., A.A.Allan, C.Hutton, C.Giupponi, F.A.Johnson. (submitted) Adaptive IWRM responses to cope with "what if?" scenarios. IN: W.A. Flügel & N.Sharma (Eds.). Applied Geoinformatics for Sustainable Integrated Water resources Management (IWRM). Results from the EU-project BRAHMATWINN. The Netherlands, Springer my contribution: definition of the framework for the evaluation of the responses, management of the case study, organization and facilitation of workshops (author of chapter) , parts of discussion and conclusions.
	Giupponi, C. & V.Giannini. Participatory Planning for Climate Change Adaptation in the BRAHMATWINN Project. Presented in: *International Congress on* Environmental *Modelling and Software*, Ottawa, Canada (5-8 July 2010) International Environmental Modelling & Software Society (iEMSs) http://www.iemss.org/iemss2010/papers/S05/S.05.12.Participatory%20planning%20for%20climate%20change%20adaptation%20in%20the%20Brahmatwinn%20Project--CARLO%20GIUPPONI.pdf my contribution: contribution to the BRAHMATWINN research project: this research was carried out under direct supervision and in coordination with Carlo Giupponi
	Giannini, V. *et al*. 2009. A participatory approach for defining response strategies to reduce risk and vulnerability from flooding in a changing climate. *IOP Conf. Ser.: Earth Environ. Sci.* **6** 362005 doi:10.1088/1755-1307/6/36/362005 http://www.brahmatwinn.uni-jena.de/fileadmin/_temp_/1_Giannini-etAL.pdf my contribution: definition of the framework for the evaluation of the responses, management of the case study, organization and facilitation of workshops (author and presenter of poster).

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All accessed December 2011

ANNEX 1: Workshop in Salzburg (Austria) October 2008

This workshop was organized with the help of Z_Gis

Agenda

TIME	GOAL	ACTIVITY
9:00	registration	
9:10	welcome	▪ introduce project
9:30	Self introduction of Participants	▪ participants present them selves and explain **why and how** they are involved in the issue, and which are their expertises (1 min max each)
9:45	Present CC storyline WS Goals, Sub-domains and strategies	▪ present storyline as defined by climate scientists and hydrologists on forecast of water availability in the next 20 years **(anticipated via EMAIL)** ▪ workshop goals ▪ present the outputs ab. **Criteria** and **Strategies** (categories + sub-categories + actions). **(anticipated via EMAIL)** ▪ Introduce next selection exercise
10:05	**BRAINSTORM**	▪ brainstorm to add missing **Strategies.** From the presented list they can add sub-categories or actions
10:50	**1° EXERCISE Selection of criteria**	▪ explanation of the selection method and how to complete the tables
11:00		▪ selection of CRITERIA ▪ definition of ROWS of the matrix
11:30	Coffee Break	
12:00	**2° EXERCISE Fill in the matrix**	▪ presentation of previous results (matrix 9x4) ▪ Explanation of the criteria weighting procedure and how to complete the questionnaires
12:10		▪ elicitation of criteria's weights ▪ filling in the matrix
12:40	Wrap up	▪ feedback on WS ▪ fill in the feedback questionnaire
13:00	END	

List of stakeholders

NAME	DEPARTMENT/ORGANISATION
Godehard Meier [Waste Water]	Wacker Chemie AG [Chemistry indudstry]
Jakob Wagner [NGO]	Sanierung Untere Salzach [Nature Protection NGO]
Norbert Altenhofer [Director]	Referat Katastrophenschutz, Landesregierung Salzburg [Disaster Protection, Federal Government]
Hans Wiesenegger [Director]	Referat Hydrographischer Dienst, Landesregierung Salzburg [Hydrological Service, Federal Government]
Wolfgang Urban [Director]	National Park Hohe Tauern
Karl Wimmer [Head of Kaprun Hydro Power]	Verbund [Hydropower company]
Ulli Vilsmaier [Coordinator and Researcher]	Leben 2014 [Project Initative; Regional Planning]

ANNEX 2: Workshop in Kathmandu (Nepal) November 2008

This workshop was organized with the help of ICIMOD, IIT-Roorkee, UniBhu, ITP, CARR

Agenda

TIME	GOAL	ACTIVITY
		24-11-2008 DAY 1 → phase one
11:30	Introduction and presentation of Response Strategies	▪ workshop goals ▪ **CC storyline** as defined by climate scientists and hydrologists on forecast scenarios (IPCC SRES) of water availability ▪ present the results of our work: **response strategies** (main categories + sub-ramifications)
12:00	**BRAINSTORMING**	▪ brainstorming to elicit **Response Strategies**: they can add sub-categories and/or actions
13:00	LUNCH	
14:00	**BRAINSTORMING**	▪ Continue exercise
14:30	Present criteria	▪ present the results of our work: **criteria**
15:00	Introduce Exercise 1	▪ Explanation of the selection method, instructions to fill table
15:10	**1st EXERCISE** **Selection of criteria**	▪ Selection of CRITERIA: 3 tables (ECO,SOC,ENV) criteria ▪ definition of ROWS of the matrix
	Elaboration of phase one	▪ **update** Response Strategies table and print ▪ Elaboration of first exercise: **insert criteria selected in tables** (weighting and matrix)
		25-11-2008 DAY 2 → phase two
9:00	Phase one results	▪ presentation of previous results (selected criteria)
9:10	Introduce Exercise 2	▪ Explanation of criteria weighting procedure and how to complete the exercise (criteria weights and evaluation matrix)
9:20	**2nd EXERCISE** **Criteria weights** **Fill in the matrix**	▪ elicitation of criteria weights ▪ Fill in the evaluation matrix
	Elaboration of phase two	▪ Elaborate results ▪ **insert results in mDSS**
		27-11-2008 DAY 4 → phase three
	mDSS	▪ Presentation of results in mDSS
	Feedback on WS	▪ Feedback on WS: discussion ▪ distribute the feedback questionnaire

List of stakeholders

COUNTRY	NAME	DEPARTMENT/ORGANISATION
Bhutan	Karma Tshethar, Executive Engineer	Department of Agriculture (Irrigation Section), Ministry of Agriculture
	Karma Dupchu, Sr. Hydrology Officer	Department of Energy (Hydromet Service Division), Ministry of Economic Affairs
	G. Karma Chhopel, Sr. Environmentalist	National Environment Commission, Water Resources
	Chimi Wangmo, Associate Lecturer	College of Science and Technology
China	Jianwei Hu, Director	Bureau of Hydrolog, Ministry of Water Resorces
	Prof. Jingshi Liu, Research Professor	Institutes of Tibetan Plateau Research, Chinese Academy of Science
	Yuji Jiang, Water Resources Lab	Hydrology and water resources Bureau of Tibet
	Kaihu Liu	Hydrology and water resources Bureau of Tibet
	Xiaoyin Guo	Chinese Academy of Meteorological Sciences
India	Nomal Chandra Das, Additional Chief Engineer	Water Resources Department, Government of Assam
	Dr. Archana Sarkar, Scientist	National Institute of Hydrology
	Dr. Partha Jyoti Das, Head, Water and Climate Programme	AARANYAK, A Scientific & Industrial Research Organisation of India
	Gideon Kharkhonger, Sr. Lecturer	North eastern Hill University, St. Edmunds College
Nepal	Dr. Dilip kumar Gautam, Sr. Divisional Hydrologist	Department of Hydrology and Meteorology
	Tirtha Raj Adhikari, Lecturer	Central Department of hydrology and Meteorology
	Kumud Raj Kafle, Assistant Professor	Department of Environmental Sciences and Engineering, Kathmandu University
	Sharad Upadhyaya, Engineer	Institute of Engineering, Tribhuwan University
	Gautam Rajkarnikar, Sr. Divisional Engineer	Water and Energy Commission Secretariate
	Bijay Kumar Pokhrel, Hydrologist Engineer	Department of Hydrology and Meteorology

ANNEX 3: Symposium in Kathmandu (Nepal) November 2009

This workshop was organized with the help of ICIMOD, IIT-Roorkee, UniBhu, ITP, CARR

Agenda

	8th November 2009
13:30 - 13:40	**Welcome address**, Dr Andreas Schild, Director General, ICIMOD
13:40 – 13:50	**Opening remarks**, Prof Hua Ouyang, Programme Manager, ICIMOD
13:50 – 14:00	**Introduction to the Symposium** , Prof Wolfgang Flügel, FSU-Jena
14:00 – 14:10	**Inaugural Address** , Chief Guest, Mr. Kishore Thapa, Secretary of WECS
14:10 – 14:15	**Vote of Thanks and Closing of Inaugural Session ,** Mats Eriksson, ICIMOD
14:15 – 14:45	Tea and coffee break and **Group Photographs**
14:45 - 15:15	Downscaling of General Circulation Model predictions in the Himalayan region; Andreas Dobler (JWG Univ. of Frankfurt)
15:15 – 15:45	Assessment of the natural environment; Petra Füreder (Z_GIS)
15:45 – 16:15	Modeling socio-economic vulnerability to floods: Comparison of methods developed for European and Asian case studies; Craig Hutton (GeoData Institute) & Stefan Kienberger (Z_GIS)
16:15 – 16:40	Tea and coffee break
16:40 – 17:00	Analysis of present IWRM practices in the Brahmaputra basin: Anita Bartosch (FSU-Jena)
17:00 – 17:30	Identification and selection of indicators of environmental change; Valentina Giannini (FEEM)
17:30 – 18:00	Using the hydrological model DANUBIA for water availability scenarios in the upper Brahmaputra basin; Monika Prasch (LMU)
18:00 – 18:10	Closing day one by Hua Ouyang (ICIMOD)
	9th November 2009
8:55 – 9:00	**Opening remarks**, Prof. Wolfgang Flügel (Friedrich-Schiller University Jena)
09:00 – 09:30	Stakeholder presentation: “Present IWRM in Upper Danube river basin”; Hans Wiesenegger (Government Salzburg)
09:30 – 10:30	The Brahmaputra River Basin Information System (BrahmaRBIS): Carsten Busch (Codematix GmbH)
10:30 - 11:00	Tea and Coffee Break
11:00 – 12:00	Presentation of likely “what-if” scenarios in the UBRB: Craig Hutton, Valentina Giannini, Stefan Kienberger, Monika Prasch, Andreas Dobler; Moderated discussion with stakeholder about defined “what-if?” scenarios Prof Wolfgang Flügel
12:00 – 13: 00	Lunch
13:00 – 15:00	Joint elaboration of response strategies and adaptive IWRM options for the Brahmaputra basin: Valentina Giannini, Prof Wolfgang Flügel
15:00 – 15:45	Discussion of IWRM options and response strategies Prof Wolfgang Flügel
15:45 – 16:15	Tea and Coffee Break
16:15 - 16:30	Upcoming and new events: PANI water twinning project between Prague and Kathmandu, Zuzana Boukalová (REC CR)
16:30 – 16:45	Water quality issues related to IWRM: Solutions for Himalayan Countries; Jan Kreuter and Jitka Znamenackova, Czech Embassy Delhi
16:45 – 17:00	Twin2Go: transfer knowledge from twinning projects to new audiences: Anita Bartosch (FSU-Jena)
17:00 – 17:30	Discussion, wrap up and closure of the symposium: Prof Wolfgang Flügel and Madhav Karki (Dep. Director, ICIMOD)

List of stakeholders

COUNTRY	NAME	DEPARTMENT/ORGANIZATION
Bhutan	Karma Dupchu	Department of Energy (Hydromet Service Division)
	G. Karma Chhopel	National Environment Commission, Water Resources
	Chimi Wangmo	College of Science and Technology
	Tashi Lhamo	Druk Green Power Corporation Limited
	Ugyen Rinzin	Department of Public Health, Ministry of Health, Bhutan
	Tenzin	Ministry of Agriculture
	Ugyen Tenzin	Royal University of Bhutan
China	Jianhu Hu	Water Resources and Hydrology Bureau, Ministry of Water Resorces and Power of China
	Jingshi Liu	Institutes of Tibetan Plateau Research, Chinese Academy of Science
	Dongqi Zhang	Chinese Academy of Meteorological Science
	Bian Duo	Institute of Tibetan Plateau Atmospheric & Environmental Science, Tibet Meteorological Bureau
	Chu Duo	Institute of Tibetan Plateau Atmospheric and Environmental Sciences, Tibet Meteorological Bureau
	Luo Xinghong	Institute of Tibetan Plateau Atmospheric and Environmental Sciences, Tibet Meteorological Bureau
	Yan XianMa	Institute of Tibetan Plateau Atmospheric and Environmental Sciences, Tibet Meteorological Bureau

	Sou Lang Duo Li	Institute of Tibetan Plateau Atmospheric and Environmental Sciences, Tibet Meteorological Bureau
	Zhigang Yang	Tibet Climate Centre, Tibet Meteorological Bureau
	Zhuo Ga	Institute of Tibetan Plateau Atmospheric and Environmental Sciences, Tibet Meteorological Bureau
	Yuping Lei	Centre for Agriculture Resource Research, IGDB CAS
India	Amiya Sharma	Rastriya Gramin Vikas Nidhi
	Rupak K. Mazumdar	Government of Assam, Director of Food and Civil Suppliers
	Dulal Chandra Goswami	Retd. Professor, Environmental Science, Guwahati University
	Trilochan Baruah	Superintending Engineer, Brahmapurtra Board (MOWR), Govt. of India
	Nawajyoti Sharma	Advisor, (Imig. Flood Control), North Eastern Council – IIT Roorki
	Pradip Sharma	Selection Grade Lecturer, Cotton College Department of Geography
	Abhijit Dutta	Secretary to the Govt. of Assam, Public Health Engineering Department, IIT-Roorki
	Roopak Goswami	Principal Corespndent, The Telegraph
	Anup Mitra	Adviser – ADB Project, Government of India
	Tapan Dutta	Retd. Professor, Govt. of India, Advisor to the Chief Minister
	Padma Sharma Goswami	Selection Grade Lecturer, Cotton College
	Nayan Sharma	Dept. of Water Resources Development & Management, Indian Institute of Roorki
Nepal	Dilip Kumar Gautam	Sr. Divisional Hydrologist, Department of Hydrology and Meteorology
	Tirtha Raj Adhikari	Central Department of hydrology and Meteorology, Tribhuvan University, Kritipur, Kathmandu
	Kumud Raj Kafle	Department of Environmental Sciences and Engineering, Kathmandu University
	Sharad Upadhyaya	Institute of Engineering, Tribhuwan University, Thapathali Campus
	Gautam Rajkarnikar	Koshi River Basin Management Cell, Water and Energy Commission Secretariat
	Bijay Kumar Pokhrel	Department of Hydrology and Meteorology
	Bed Kumar Dhakal	Department of National Parks and Wildlife Conservation
	Shreekamal Duibedi	Department of Water Induced Disaster Prevention
	Neera Shrestha Pradhan	WWF – Nepal
	Dhurba R. Pant	International Water Management Institute (IWMI)-Nepal, Department of Irrigation
	Luna Bharati	International Water Management Institute (IWMI)-Nepal, Department of Irrigation
	Kiran Shankar Yogacharya	SOHAM – Nepal
	Jagat Kumar Bhusal	SOHAM – Nepal
	Dhiraj Pradhananga	SOHAM-Nepal
	Narendra Man Shakya	Civil Engineering Department, Institute of Engineering
	Madan Lal Shrestha	Nepal Academy of Science and Technology
	Adarsha Prasad Pokharel	Bhanimandal
	Ram Chandra Khanal	IUCN Nepal

Pakistan	Farrah Zulfiqar	Department of Earth Sciences
	Zulfiqar Ahmad	Department of Earth Sciences, Quaid-i-Azam University
BRAHMATWINN	Kimberly Casey	University of Oslo, Department of Geosciences
	Andreas Dobler	Goetr-University of Frankfurt
	Bodo Ahrens	Goetr-University of Frankfurt
	Craig Hutton	GeoData Institute, University of Southampton
	Monika Prasch	Ladwig Maximiliaus University
	Valentina Giannini	Fondazione Eni Enrico Mattei
	Petra Füreder	University of Salzburg
	Stefan Kienberger	Centre for Geoinformatics, Salzburg University
	Ivo Cerny	VODNÍ ZDROJE
	Zuzana Boukalová	Head of the International Department, VODNÍ ZDROJE
	Anita Bartosch	FRIEDRICH SCHILLER UNIVERSITY OF JENA, Department of Geoinformatics
	Jörg Pechstädt	FRIEDRICH SCHILLER UNIVERSITY OF JENA, Department of Geoinformatics
	Carsten Busch	Codematix GmbH
	Boehm Cristoph	MD – GDS
	Hans Wiesenegger	Head of Department, Regional Government of Salzburg
	Norbert Exler	University of Vienna
	Georg Janauer	University of Vienna
	Wolfgang-Albert Flügel	Department of Geoinformatics, Hydrology and Modelling, Friedrich-Schiller University (FSU-Jena)
	Andrew Allan	University of Dundee
	Znamenackova Jitka	Diplomat, Embassy of the Czech Republic in India
	Kzeoter Jan	Diplomat, Embassy of the Czech Republic in India
ICIMOD	Hua Ouyang	Program Manager, IWHM
	Mats Eriksson	Water Specialist
	Arun B. Shrestha	Climate Specialist
	Rajesh Thapa	Land & Water Analyst
	Sagar R. Bajracharya	Satellite Hydrology Officer
	Binod Gurung	
	Sarita Joshi	Sr. Program Assistant
	Rekha Rasaily	Program Assistant

ANNEX 4: Research in Guatemala

Annex: questionnaire

Buenos días,
Estoy haciendo una investigación sobre Reducción de riesgo a desastre en Ca' Foscari Universidad de Venecia (Italia). El enfoque de esta investigación es comparar opiniones sobre cuales son los elementos de riesgo, y las medidas para reducirlo. Tomaré en cuenta las opiniones de varios actores locales, por lo cual estoy interesada en la suya. En esta primera fase le pido favor de llenar la encuesta en línea, luego le contactaré para una validación. Al final de mi investigación compartiré los resultados entre los que han participado y trataré de publicarlos en una revista científica (en cuyo caso sus datos personales no serán divulgados). Me puede contactar para aclarar cualquier duda que tenga antes de empezar la encuesta.
Las definiciones y terminos usados son tomados de UN-ISDR:
http://unisdr.org/files/7817_UNISDRTerminologySpanish.pdf
Muchas gracias, saludos, Valentina Giannini
valentina.giannini@cmcc.it **+39.0412700448**

1. Datos personales

- ❑ Nombre.______________
- ❑ Organización o comunidad _____________________
- ❑ Rol _____________________
- ❑ Edad _____________________
- ❑ Género _____________________
- ❑ Escolaridad _____________________
- ❑ Correo electrónico _____________________
- ❑ Teléfono _____________________

AMENAZA HIDROMETEOROLÓGICA: Un proceso o fenómeno de origen atmosférico, hidrológico u oceanográfico que puede ocasionar la muerte, lesiones u otros impactos a la salud, al igual que daños a la propiedad, la pérdida de medios de sustento y de servicios, trastornos sociales y económicos, o daños ambientales.

2. Considerando solo amenazas causadas por eventos hidrometeorológicos, identifique los tipos de amenazas que ocurren en Guatemala:

- ❑ Inundación
- ❑ Deslave o derrumbe
- ❑ Sequía
- ❑ Incendio forestal
- ❑ Granizada
- ❑ Oleaje o marejada
- ❑ Ciclón o huracán
- ❑ Vendavales
- ❑ Tornado
- ❑ Ola de calor
- ❑ Ola de frío
- ❑ otro (indicar cuál) _____________________

3. Marque la casilla con los elementos impactados por las amenazas identificadas en la pregunta anterior:

Llenar considerando solo las columnas con amenazas seleccionadas en la pregunta 2

	Inundación	derrumbe Deslave o	Sequía	Incendio forestal	Granizada	Oleaje o marejada	Ciclón o huracán	Vendavales	Tornado	Ola de calor	Ola de frío	otro: ______
Playas												
Líneas costeras												
Esteros y deltas												
Humedales												
Ecosistemas marinos												
Ecosistemas de agua dulce												
Ecosistemas terrestres												
Recursos hídricos												
Acuíferos												
Lagos												
Ríos												
Biodiversidad												
áreas protegidas												
áreas de bosque												
áreas pesqueras												
áreas agrícolas												
áreas urbanas												
Comunidades/pueblos												
Poblaciones												
Otro: ________												

Estas amenazas son causadas por eventos hidrometeorológicos: en relacion a cada evento identificar cuando se da riesgo de desastre.
RIESGO DE DESASTRES: Las posibles pérdidas que ocasionaría un desastre en términos de vidas, las condiciones de salud, los medios de sustento, los bienes y los servicios, y que podrían ocurrir en una comunidad o sociedad particular en un período específico de tiempo en el futuro.

4. **Indique cuando y como los CICLÓNES O HURACÁNES los/las ponen bajo riesgo:**
Ejemplo: siempre/nunca, indicar bajo qué condiciones o temporada, o si hay lugares expuesto a esto evento describir el lugar...

5. **Indique cuando y como las LLUVIAS los/las ponen bajo riesgo:**
Ejemplo: siempre/nunca, indicar bajo cuales condiciones o temporada, o si hay lugares expuesto a esto evento describir el lugar...

6. **Indique cuando y como las MAREJADAS los/las ponen bajo riesgo:**
Ejemplo: siempre/nunca, indicar bajo cuales condiciones o temporada, o si hay lugares expuesto a esto evento describir el lugar...

7. **Indique cuando y como VENDAVALES o VIENTOS los/las ponen bajo riesgo:**
Ejemplo: siempre/nunca, indicar bajo cuales condiciones o temporada, o si hay lugares expuesto a esto evento describir el lugar...

8. **Indique cuando y como OLAS DE CALOR los/las ponen bajo riesgo:**
Ejemplo: siempre/nunca, indicar bajo cuales condiciones o temporada, o si hay lugares expuesto a esto evento describir el lugar...

9. Indique cuando y como OLAS DE FRIO los/las ponen bajo riesgo:
Ejemplo: siempre/nunca, indicar bajo cuales condiciones o temporada, o si hay lugares expuesto a esto evento describir el lugar...

10. Ciertas actividades humanas aumentan el riesgo a desastres debido a amenazas hidrometeorológicas, indique cuales:
Llenar considerando solo las columnas con amenazas seleccionadas en la pregunta 2

	Inundación	Deslave o derrumbe	Sequía	Incendio forestal	Granizada	Oleaje o marejada	Ciclón o huracán	Vendavales	Tornado	Ola de calor	Ola de frío	otro: ____
Construir en tierras marginales												
Construir en la orilla del mar, a nivel del mar												
Construir en medio de una ladera de montaña												
Contruir a la base de una ladera												
Construir en terrazas de laderas de montañas												
Construir en la orilla de un río o de un lago												
Construir en planicies cercanas a ríos o lagos												
Pobreza												
Agricultura de corte y quema												
Deforestación												
Construir diques u otras defensas												
Impermeabilizar suelos												
MAS???												

11. Añadir otras actividades humanas que pueden causar riesgo, identificando cual riesgo causan

12. Cuando fue la ultima vez que hubo y con que frecuencia occurren los eventos?
Llenar considerando solo las amenazas seleccionadas en la pregunta 2

	cuando? indicar dias, semanas, meses, años	con que frecuencia estan/han estado ocurriendo?
Inundación		
Deslave o derrumbe		
Sequía		
Incendio forestal		
Granizada		
Oleaje o marejada		
Ciclón o huracán		
Vendavales		
Tornado		
Ola de calor		
Ola de frío		
Otro (indicar cuál)________		

CAPACIDAD DE AFRONTAMIENTO: La habilidad de la población, las organizaciones y los sistemas, mediante el uso de los recursos y las destrezas disponibles, de enfrentar y gestionar condiciones adversas, situaciones de emergencia o desastres.

13. En caso de emergencia: que se necesita hacer?

Ejemplos:

- **ir a un lugar o edificio seguro (indicar cual)**
- **salir de su casa/quedarse en su casa, subir a las plantas altas de su casa**
- **subir a un árbol o cerro, ir al bosque/salir del bosque**
- **alejarse del mar, del rio, del lago**

Llenar considerando solo las amenazas seleccionadas en la pregunta 2

	Indicar que se necesita hacer
Inundación	
Deslave o derrumbe	
Sequía	
Incendio forestal	
Granizada	
Oleaje o marejada	
Ciclón o huracán	
Vendavales	
Tornado	
Ola de calor	
Ola de frío	
Otro (indicar cuál) ________________	

14. Cuál es la fuente de información reconocida que indica que hacer durante la emergencia?

- ❑ CONRED (Coordinadora Nacional para la Reducción de Desastres, Guatemala)
- ❑ Líder comunitario (indicar cuál) ____________________
- ❑ Radio
- ❑ Policía
- ❑ Bomberos
- ❑ Otra autoridad (indicar cuál) ____________________
- ❑ ONG
- ❑ Cruz roja
- ❑ Persona conocida (indicar cuál) ____________________
- ❑ Taller (indicar cual) ____________________
- ❑ Otro (indicar cual) ____________________

15. Quien está a cargo de tomar las decisiones sobre que hacer durante la emergencia?

- ❑ CONRED (Coordinadora Nacional para la Reducción de Desastres, Guatemala)
- ❑ Líder comunitario
- ❑ Policía
- ❑ Bomberos
- ❑ Otra autoridad local (indicar) ____________________
- ❑ ONG ____________________
- ❑ Cruz roja
- ❑ otro (indicar)

16. Que se necesita hacer para la gestión de una emergencia?

REDUCCIÓN DEL RIESGO DE DESASTRES: El concepto y la práctica de reducir el riesgo de desastres mediante esfuerzos sistemáticos dirigidos al análisis y a la gestión de los factores causales de los desastres, lo que incluye la reducción del grado de exposición a las amenazas, la disminución de la vulnerabilidad de la población y la propiedad, una gestión sensata de los suelos y del medio ambiente, y el mejoramiento de la preparación ante los eventos adversos.

17. Quien tiene el mandato para hacer reducción de riesgo?

- ❑ CONRED (Coordinadora Nacional para la Reducción de Desastres, Guatemala)
- ❑ Líder comunitario
- ❑ Policía
- ❑ Bomberos
- ❑ Otra autoridad local (indicar) ____________________
- ❑ ONG ____________________
- ❑ Cruz roja
- ❑ otro (indicar)

1. Que está haciendo ahora su institucion/comunidad para reducir el riesgo a desastre, causado por amenazas hidrometeorológicas?

2. Que necesitaría hacer cada organización para la gestión del riesgo a desastre, causado por amenazas hidrometeorológicas?

	CONRED	Líder comunitario	Policía	Bomberos	Otra autoridad local (indicar)	ONG	Cruz roja	otro (indicar)
concientización/sensibilización pública								
disminuir la degradación ambiental								
definir en un mapa zonas de riesgo y no construir en estas								
código de construcción								
planificación/ordenamiento territorial								
planes y diposiciones institucionales								
construir y mantener terrazas en laderas								
construcciónes físicas para reducir o evitar los posibles impactos de las amenazas, como diques								
ampliación y/o rediseño de colectores de lluvias								
reforzamiento de riberas y dragado de cauces								
reforestacion en las laderas								
reforestacion en las orillas de los rios								

3. **Que acciones adicionales su institución/comunidad debería/podría hacer para reducir o prevenir los riesgos a desastres, causados por amenazas hidrometeorológicas?**
4. **Que se necesitaría hacer para la gestión del riesgo a desastre, causado por amenazas hidrometeorológicas?**

Llenar considerando solo las columnas con amenazas seleccionadas en la pregunta

	Inundación	derrumbe Deslave o	Sequía	Incendio forestal	Granizada	Oleaje o marejada	Ciclón o huracán	Vendavales	Tornado	Ola de calor	Ola de frío	otro: ______
concientización/sensibilización pública												
disminuir la degradación ambiental												
definir en un mapa zonas de riesgo y no construir en estas												
código de construcción												
planificación/ordenamiento territorial												
planes y diposiciones institucionales												
construir y mantener terrazas en laderas												
construcciónes físicas para reducir o evitar los posibles impactos de las amenazas, como diques												
ampliación y/o rediseño de colectores de lluvias												
reforzamiento de riberas y dragado de cauces												
reforestacion en las laderas												
reforestacion en las orillas de los rios												

5. **Añadir otras medidas, planes, programas, etc. para la reducción del riesgo de desastre**

6. **Porque decidió ser parte de esta investigación? Cuál podría ser la ventaja para usted, su organizacion o comunidad?**

7. **Por favor tome esta oportunidad si quiere añadir algo.**

Muchas gracias por su colaboración.
Analizaré sus respuestas y haré un mapa cognitivo con la informacion que compartió conmigo. Cuando termine el mapa, volveré a contactarle para que usted lo valide y modificarlo en caso necesario. Luego le pediré hacer un ejercicio para medir la fuerza de cada concepto identificado. Cuando tenga esta información de todas las personas que contacté empezaré el analis de datos para escribir el ensayo. Al final espero tener la oportunidad de vernos para compartir estos resultados esperando que sean útiles para seguir adelante en su trabajo.
Saludos, Valentina Giannini valentina.giannini@cmcc.it **+39.0412700448**

Annex: List of stakeholders

An additional list of roughly 100 stakeholders, who were involved by the Comisón, were contacted, but are not listed here.

INTERNATIONAL	United Nations International Strategy for Disaster Reduction Secretariat - The Americas (UNISDR - AM) http://www.eird.org/index-esp.html	Salvano Briceño Demetrio Innocenti
	United Nations Platform for Space-based Information for Disaster Management and Emergency Response http://www.un-spider.org/	Juan Carlos Villagran de Leon
	Bureau for Crisis Prevention and Recovery - UNDP (BCPR-UNDP)	
	United Nations Development Programme (UNDP) http://www.pnud.org.gt/	
	Global Facility for Disaster Reduction and Recovery, the (GFDRR) http://www.gfdrr.org/gfdrr/	
	Inter-American Development Bank (IDB) http://www.iadb.org/en/countries/guatemala/guatemala-and-the-idb,1059.html	Juan José Taccone
	World Bank Institute (WBI) http://wbi.worldbank.org/wbi/	
	World Bank (WB)	Federica Ranghieri
REGIONAL	Centro de Coordinacion para la Prevencion de los Desastres Naturales en America Central (CEPREDENAC)	
NATIONAL	CONRED	S.Cordon I.Samines R. Deleon Z. Gomez
	MINEDUC	Guadalupe
	MAGA	Edwin
	MARN	Ana Mendoza
	SESAN	Lidia Ortiz
LOCAL	Embajada Indigena	Ofelia, Giovany
	Maya	Claudia, Juan
	Xinca	Espectacion
	Garifuna	Berta Ingrid
NGO	Red Cross/Red Crecent Climate Centre	
	CARE Nederlands	Julian Burgos
	CARE Guatemala	Salvador Casado Cristóbal Dora Arriola Ingrid.Arias
	Wetlands International	Alejandro Jimenez

		Julio Montes De Oca Lugo
	Asprode-Caritas	Arnulfo Ayala
	Red Cross Guatemala	Teresa Marroquin
ACADEMIA	Universidad San Carlos, Maestría en Gestión para la Reducción del Riesgo	
	Universidad Rafael Landívar, Diplomado en Gestion de Riesgo	
	FLACSO	Allan Lavell
	King's College London	Navarrete, Pelling, Redclift

Annex: centrality

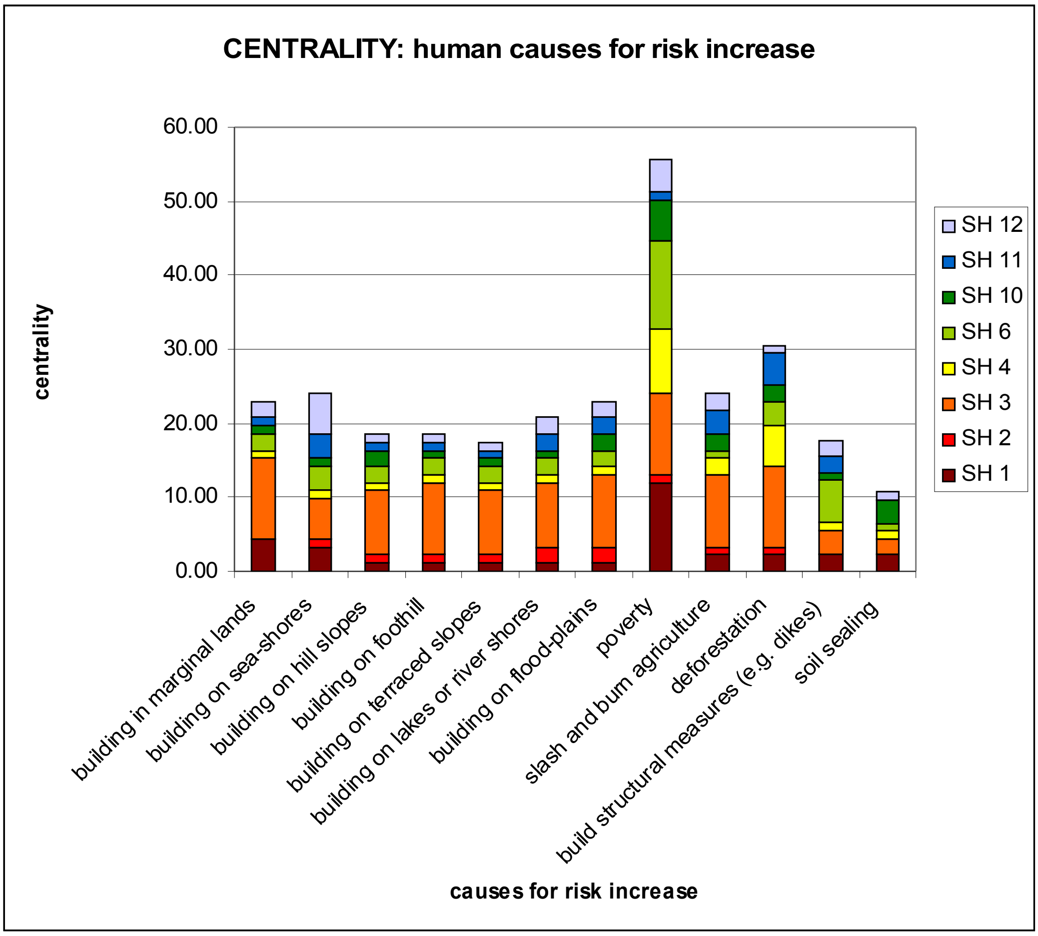


Figure 33. centrality: human causes for risk increase (elaboration made with FCMapper)

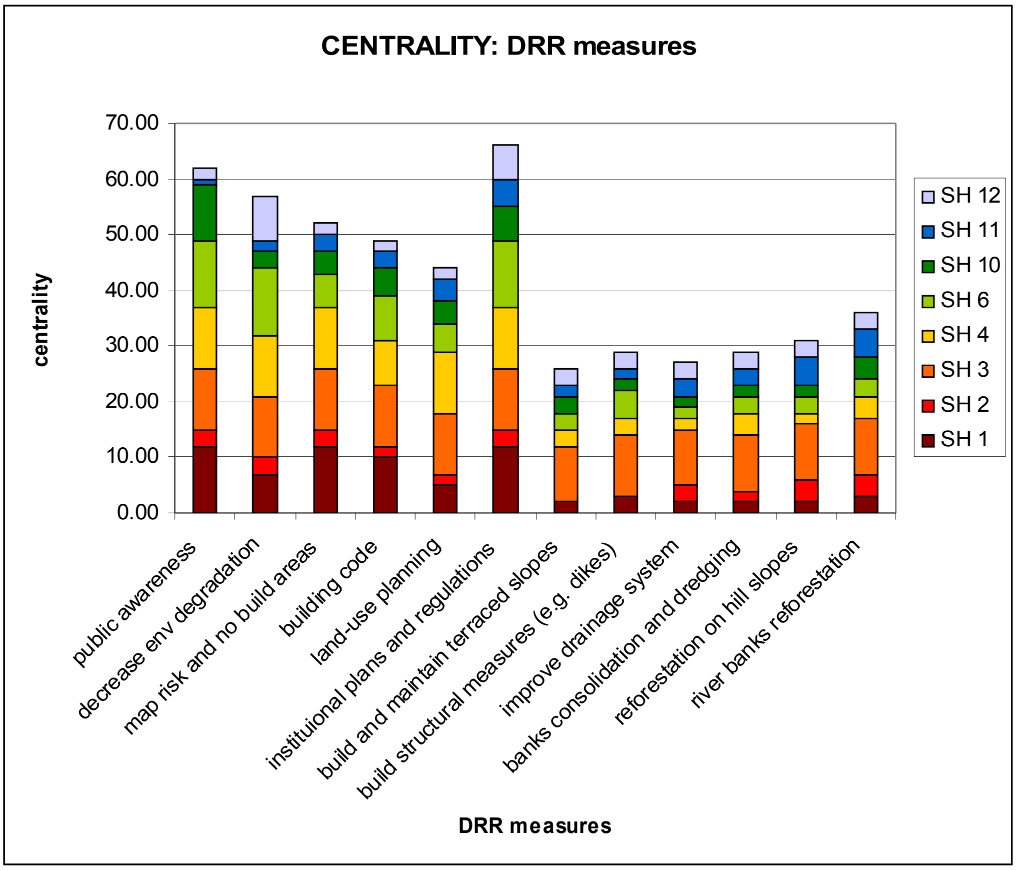


Figure 34. centrality: DRR measures (elaboration made with FCMapper)

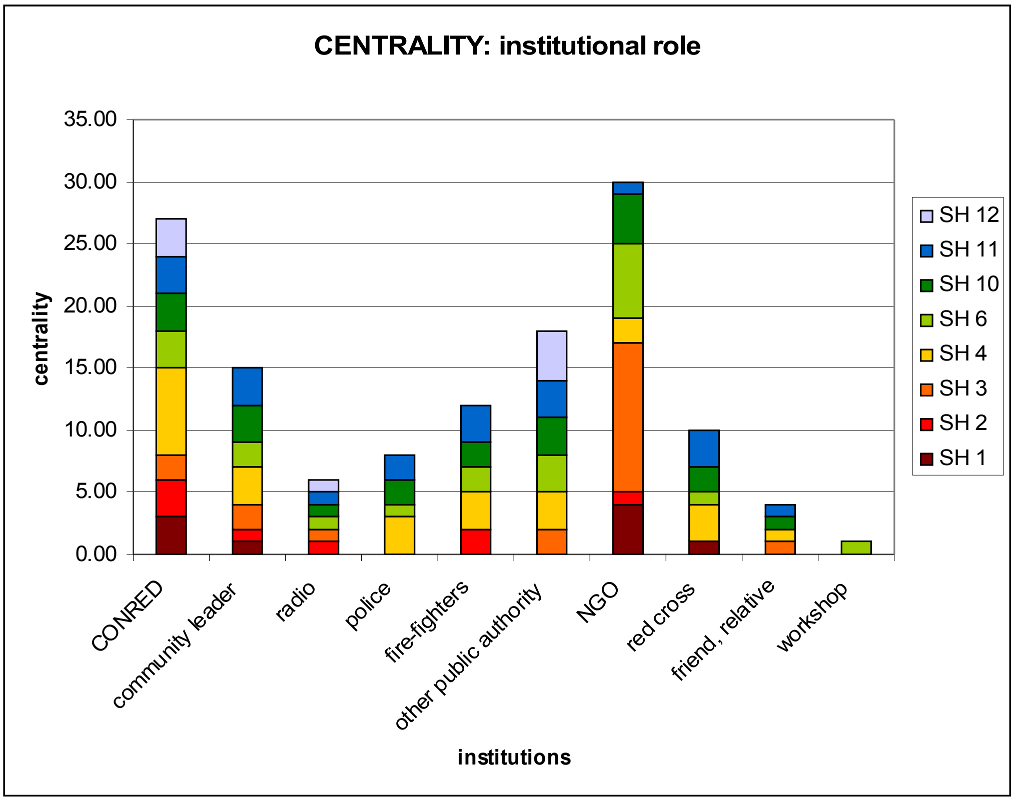
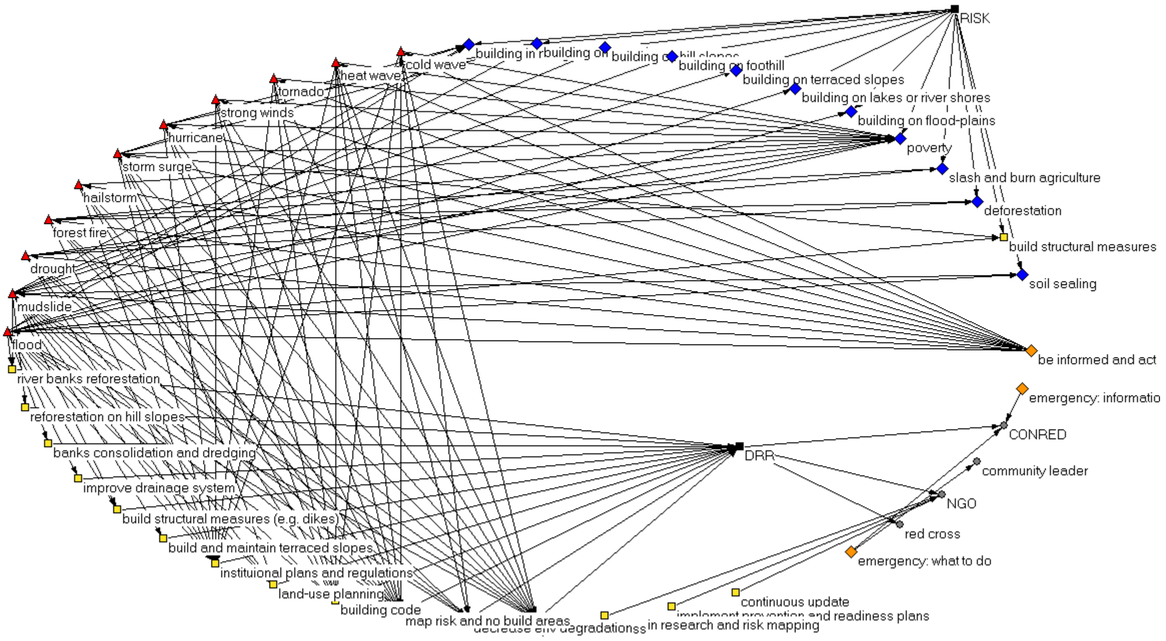


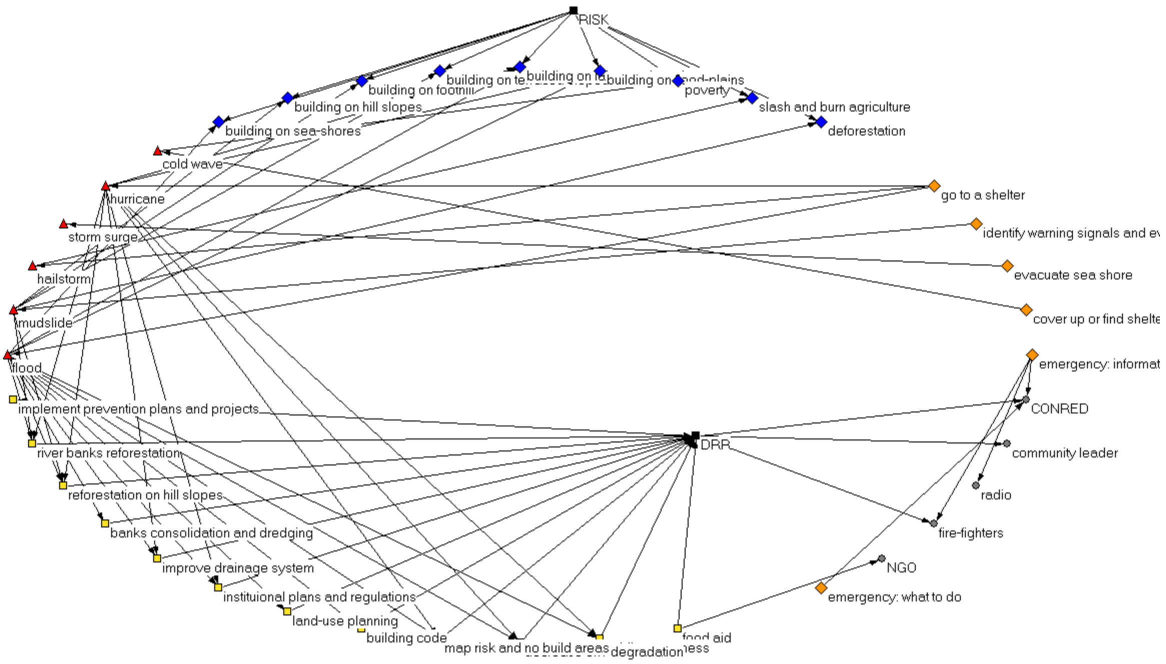
Figure 35. centrality: institutional role (elaboration made with FCMapper)

Annex: cognitive maps of stakeholders (SH1 to SH 11)

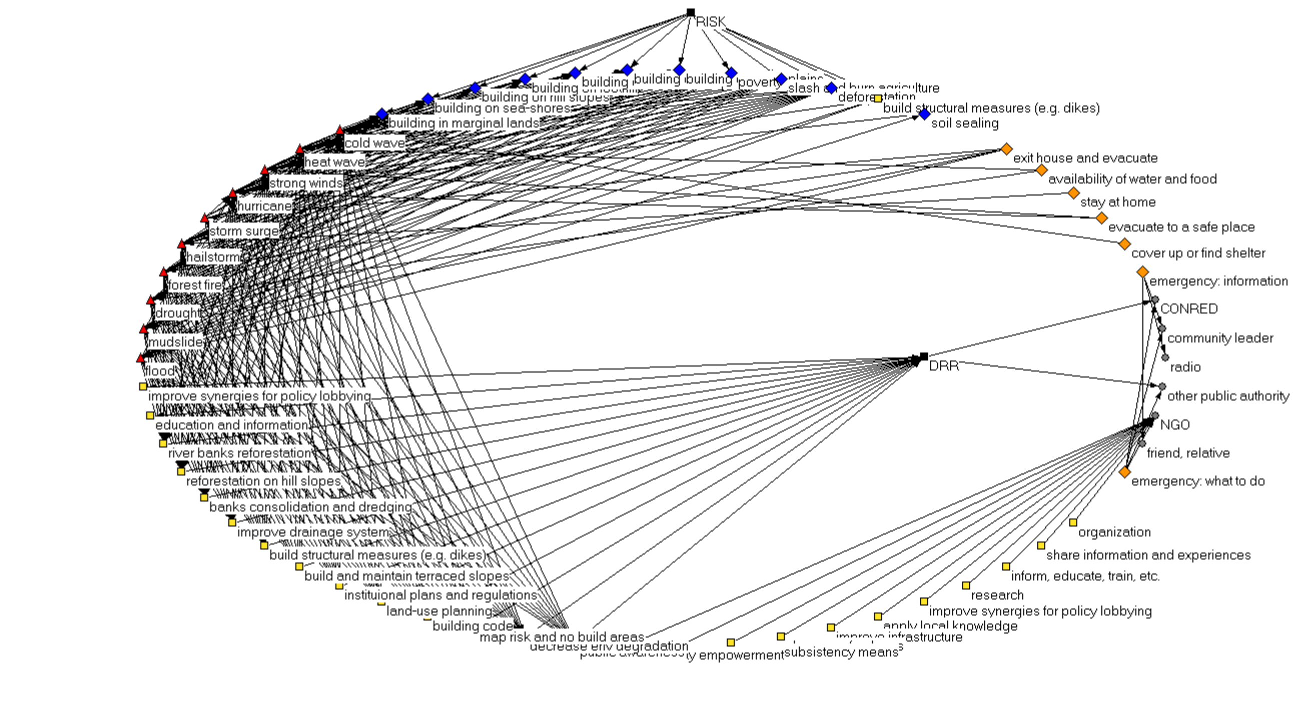
SH 1



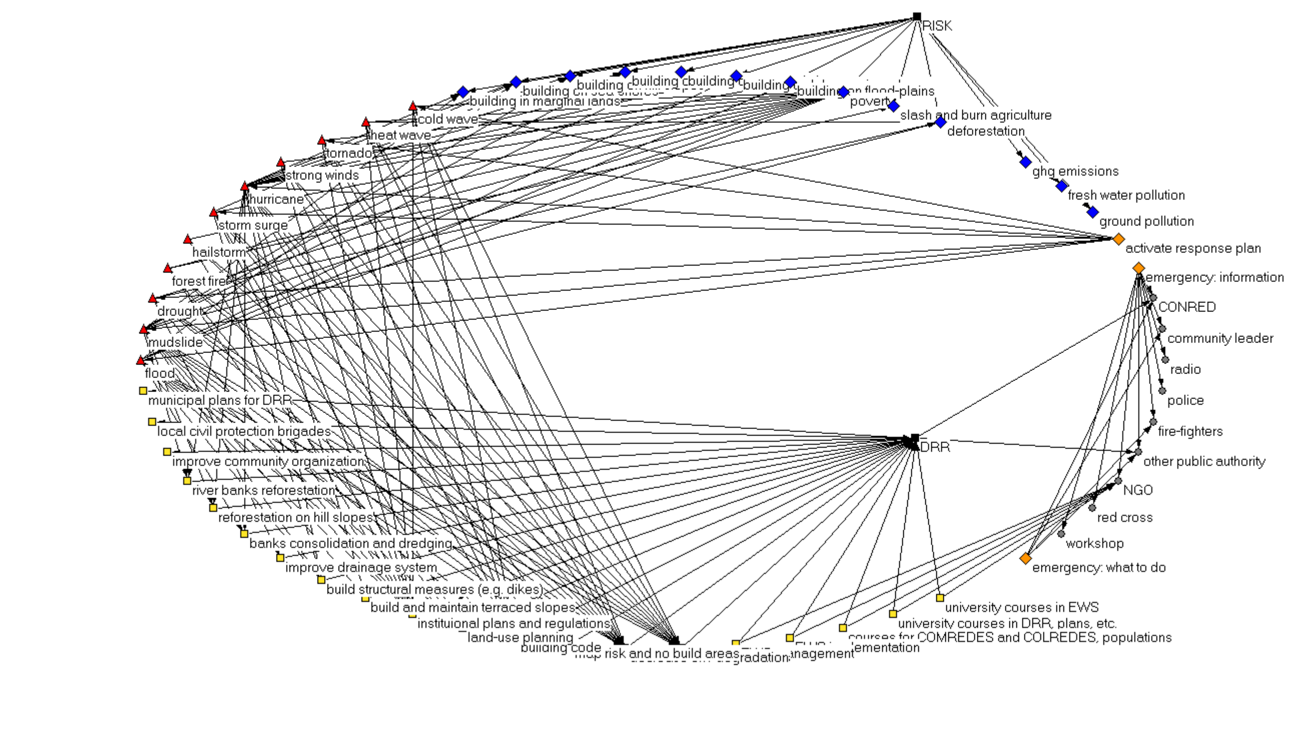
SH 2



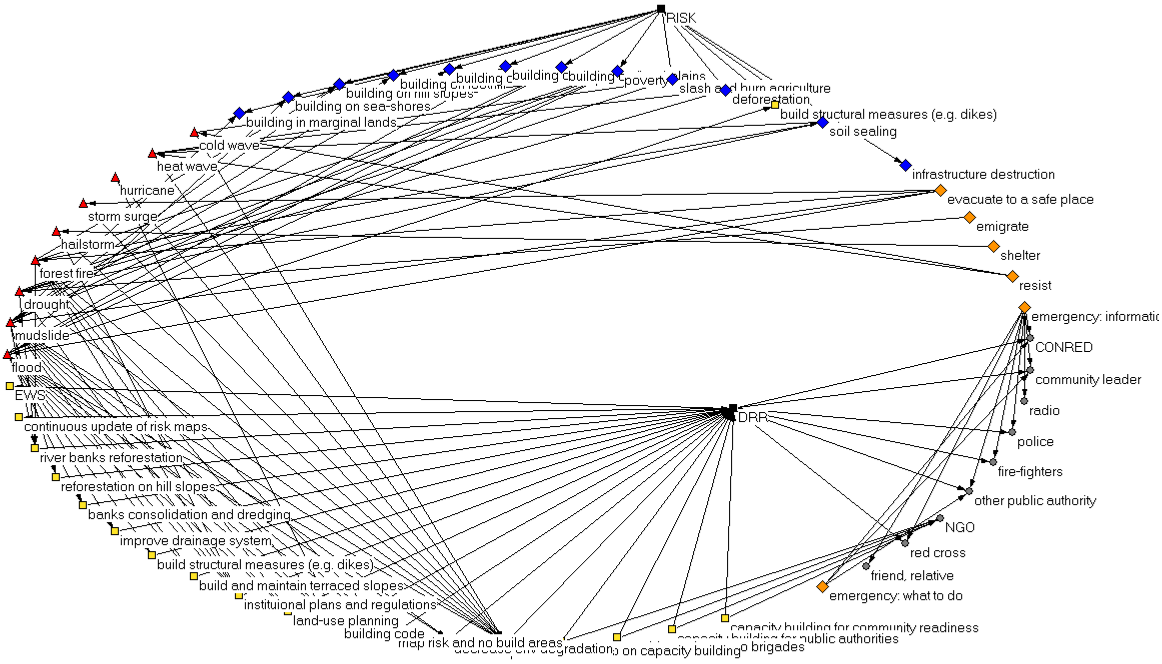
SH 3


RISK
building on hill slopes
building on sea-shores
building in marginal lands
poverty
slash and burn agriculture
deforestation
build structural measures (e.g. dikes)
soil sealing
cold wave
heat wave
strong winds
hurricane
storm surge
hailstorm
forest fire
drought
mudslide
flood
exit house and evacuate
availability of water and food
stay at home
evacuate to a safe place
cover up or find shelter
emergency: information
CONRED
community leader
radio
DRR
other public authority
NGO
friend, relative
emergency: what to do
improve synergies for policy lobbying
education and information
river banks reforestation
reforestation on hill slopes
banks consolidation and dredging
improve drainage system
build structural measures (e.g. dikes)
build and maintain terraced slopes
instituional plans and regulations
land-use planning
building code
map risk and no build areas
organization
share information and experiences
inform, educate, train, etc.
research
improve synergies for policy lobbying
apply local knowledge
subsistency means

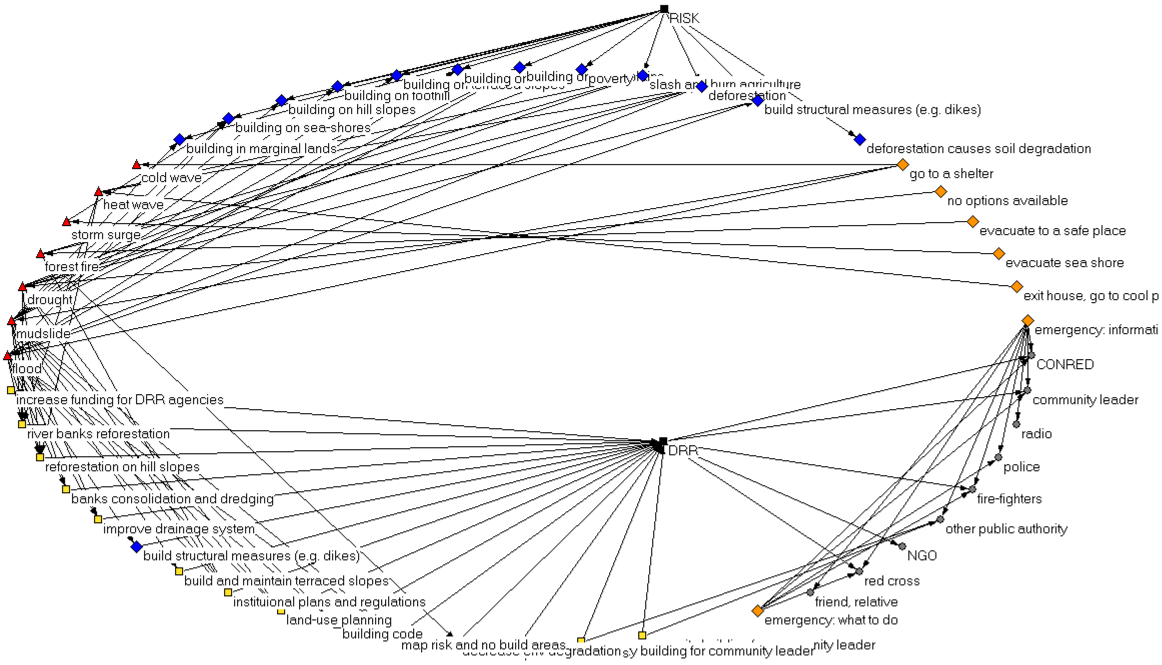
SH 6

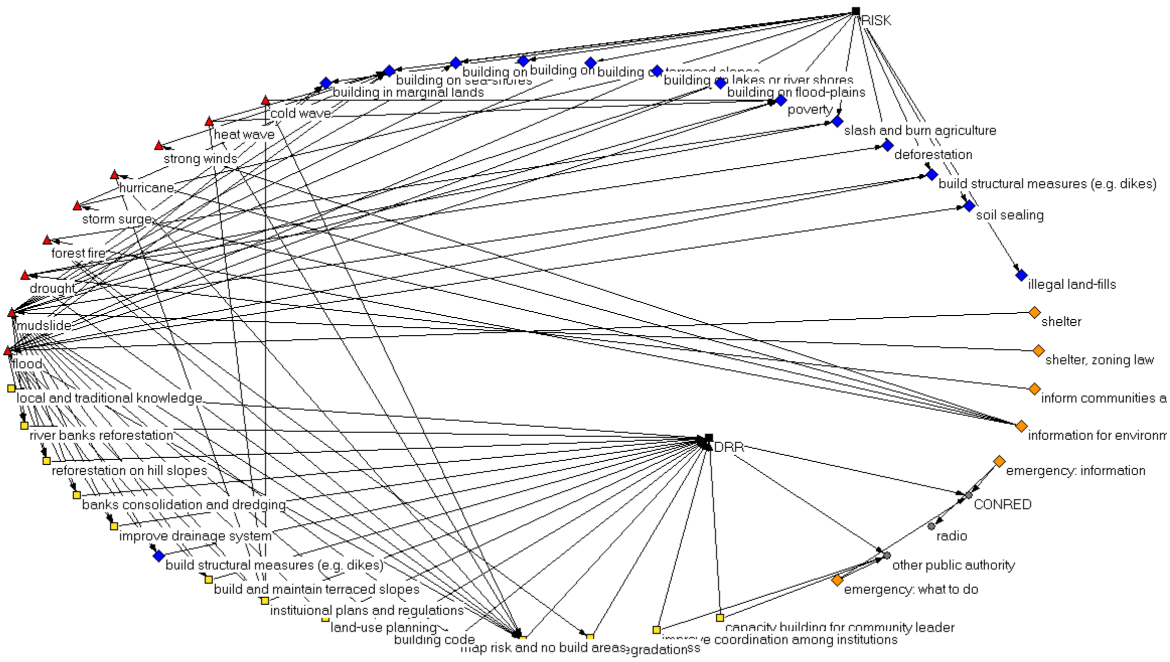

RISK
building in marginal lands
poverty
slash and burn agriculture
deforestation
ghg emissions
fresh water pollution
ground pollution
activate response plan
cold wave
heat wave
tornado
strong winds
hurricane
storm surge
hailstorm
forest fire
drought
mudslide
flood
emergency: information
CONRED
community leader
radio
police
fire-fighters
other public authority
NGO
red cross
workshop
emergency: what to do
DRR
municipal plans for DRR
local civil protection brigades
improve community organization
river banks reforestation
reforestation on hill slopes
banks consolidation and dredging
improve drainage system
build structural measures (e.g. dikes)
build and maintain terraced slopes
instituional plans and regulations
land-use planning
building code
map risk and no build areas
university courses in EWS
university courses in DRR, plans, etc.
courses for COMREDES and COLREDES, populations

SH 10


RISK
building on hill slopes
building on sea-shores
building in marginal lands
slash and burn agriculture
deforestation
build structural measures (e.g. dikes)
soil sealing
infrastructure destruction
evacuate to a safe place
emigrate
shelter
resist
CONRED
community leader
radio
police
fire-fighters
other public authority
NGO
red cross
friend, relative
emergency: what to do
capacity building for community readiness
cold wave
heat wave
hurricane
storm surge
hailstorm
forest fire
drought
mudslide
flood
EWS
continuous update of risk maps
river banks reforestation
reforestation on hill slopes
banks consolidation and dredging
improve drainage system
build structural measures (e.g. dikes)
build and maintain terraced slopes
instituional plans and regulations
land-use planning
building code
map risk and no build areas
DRR

SH 11


RISK
building on hill slopes
building on sea-shores
building in marginal lands
slash and burn agriculture
deforestation
build structural measures (e.g. dikes)
deforestation causes soil degradation
go to a shelter
no options available
evacuate to a safe place
evacuate sea shore
CONRED
community leader
radio
police
fire-fighters
other public authority
NGO
red cross
friend, relative
emergency: what to do
cold wave
heat wave
storm surge
forest fire
drought
mudslide
flood
increase funding for DRR agencies
river banks reforestation
reforestation on hill slopes
banks consolidation and dredging
improve drainage system
build structural measures (e.g. dikes)
build and maintain terraced slopes
instituional plans and regulations
land-use planning
building code
map risk and no build areas
DRR

SH 12	

RISK
building on sea-shores
building in marginal lands
building on lakes or river shores
building on flood-plains
poverty
slash and burn agriculture
deforestation
build structural measures (e.g. dikes)
soil sealing
illegal land-fills
shelter
shelter, zoning law
inform communities a
information for environm
emergency: information
CONRED
radio
other public authority
emergency: what to do
capacity building for community leader
improve coordination among institutions
map risk and no build areas
building code
land-use planning
instituional plans and regulations
build and maintain terraced slopes
build structural measures (e.g. dikes)
improve drainage system
banks consolidation and dredging
reforestation on hill slopes
river banks reforestation
local and traditional knowledge
flood
mudslide
drought
forest fire
storm surge
hurricane
strong winds
heat wave
cold wave
DRR

Estratto per riassunto della tesi di dottorato

Studente: Valentina Giannini matricola: 955550

Dottorato: Scienza e Gestione dei Cambiamenti climatici

Ciclo: 24°

Titolo della tesi : Knowledge sharing among and within stakeholder groups to cope with climate related risks.

La condivisione del sapere attraverso e all'interno dei gruppi locali per affrontare i rischi derivanti dal clima.

Abstract:

Methods to operationalize climate change adaptation are explored by developing tools for knowledge integration within participatory processes. Two paradigms are taken into consideration, and case studies are developed in relation to them. The first paradigm is Integrated Water Resources Management and the case study used is the research project BRAHMATWINN. The second paradigm is Disaster Risk Reduction (DRR) and the case study is identified based upon a knowledge harmonization process taking place in Guatemala. Three are the main results:

1. the Integrated Indicator Table useful to establish a biunivocal relation between research outcomes and stakeholders' needs;
2. the Gap Analysis Matrix useful to identify governance and policy gaps in the law and its implementation with respect to flood risk;
3. the Total Cognitive Map useful to collect and analyse visions stakeholders have on risk and DRR, and to identify and improve possible synergies among institutions and organizations dealing with DRR.

Sono sviluppati metodi per rendere operativo l'adattamento ai cambiamenti climatici a partire da processi partecipativi per l'armonizzazione del sapere. Il primo paradigma affrontato è la gestione integrata delle risorse idriche, caso studio è il progetto BRAHMATWINN; il secondo paradigma è la gestione del rischio, con un caso studio fondato su un progetto di armonizzazione delle conoscenze in corso in Guatemala. Tre sono i risultati:

1. la tabella integrata degli indicatori, mediante la quale si è stabilita una relazione biunivoca fra risultati della ricerca e necessità degli attori locali;
2. la matrice per l'analisi delle carenze di politiche per il rischio inondazione, in cui sono identificati ritardi nella legislazione e nella sua implementazione;
3. la mappa cognitiva totale, attraverso cui si possono raccogliere ed analizzare le visioni che gli attori locali hanno sul rischio e sulla sua gestione, per identificare e migliorare le sinergie possibili fra istituzioni che si occupano di gestione del rischio.

Firma della studentessa

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