“NAture Insurance value: Assessment and Demonstration”

NAIAD

SC5-09-2016 Operationalising insurance value of ecosystems
Grant Agreement nº 730497

Deliverable 3.1

Ambiguity analysis in social risk perception report

Due date of deliverable: 01/12/2017
Actual date of submission: 30/11/2017
Date of revised deliverable submission: 24/09/2018 – 31/10/2018

Start date of project: 01-12-2016
Duration: 36 months
Name of partner responsible for deliverable: CNR-IRSA
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Dissemination Level		
PU	Public	**X**
CO	Confidential, only for members of the consortium (including the Commission Services)	

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730497.

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EDITION INFORMATION

Table 1: Versions

VERSION	EDITION DATE	MODIFICATION	WRITTEN BY	CONTROLLED BY
1	20-11-17	FIRST EDITION	RAFFAELE GIORDANO, ALESSANDRO PAGANO, STEPHANIA SANTORO, IRENE PLUCHINOTTA (CNR-IRSA)	RAFFAELE GIORDANO
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REVISION	06-09-18	EC REVISION		EC-PO
REVISION	21-09-18	AUTHOR REVISION	RAFFAELE GIORDANO	COORDINATORS
REVISION	24-09-18	CO REVISION-SUBMISSION	LAURA VAY (PM)	COORDINATORS
REVISION	31-10-18	EC REVISION		EC-PO
REVISION	31-10-18	CO REVISION-SUBMISSION		LAURA VAY (PM), RAFFAELE GIRODANO

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EXECUTIVE SUMMARY

Designing and implementing Nature-based Solutions (NBS) for copying with water-related disasters is basically a collective process, involving several decision-actors, both institutional and non-institutional. The main scope of this work is to detect and analyse potential barriers hampering the effectiveness of the risk management decision-making processes. Among the others, we refer to two key barriers to be addressed, i.e. the ambiguity in risk perception and the lack of interactions among the different decision-actors. Ambiguity refers to the existence of different, equally valid, and potentially conflicting ways of framing a problem. The work done in several NAIAD demos aims at translating ambiguity from the cause of discrepancy among decision-actors to a source of creativity in the decision-making process.

To this aim, two methodologies were implemented sequentially in the NAIAD demos, i.e. the Problem Structuring Method, and specifically the Fuzzy Cognitive Mapping (FCM), and the Social Network Analysis (SNA). The FCM implementation was meant to collect, structure and analyse the stakeholders' risk perception. The analysis allowed us to identify the most central elements in the risk perceptions model, that is, the issues that, according to the stakeholders' understanding, have to be addressed in order to deal with water-related risks. The results of this analysis are used to support the subsequent phases of the NAIAD implementation in the demos, that is, the design and selection of the most suitable combination and NBS. The SNA was implemented to unravel the complex network of interactions taking place during the different phases of a risk management decision-making process. Both formal and informal interactions were accounted for. The analysis allowed to identify: i) the key elements – i.e. actors, information and tasks – in the network, that is, those elements that can facilitate the cooperation in risk management; ii) the vulnerabilities, that is, the elements that could represent a barrier to the effectiveness of the collective risk management process.

Finally, preliminary conclusions are described in this document concerning how to overcome potential barriers to the design and implementation of NBS. As such, this deliverable provides useful hints to the remaining tasks in WP3, support the implementation of WP4 and WP5. Specifically: i) it supports the development of a set of indicators for the assessment of the NBS effectiveness (T3.4, and WP4); ii) it allows the *ex-ante* evaluation of the NBS social acceptance (T3.5); iii) it contributed to the integration of stakeholders' knowledge into the System Dynamic Model (T3.3 and WP5).

1. INTRODUCTION – THE ROLE OF RISK PERCEPTION IN RISK MANAGEMENT

Governing environmental processes aiming at managing/reducing the water related risks affecting the anthropic system - i.e. a system in which four main categories of processes, such as infrastructure, built environment/planning, administration and human services, interact each other – claims for approaches capable to deal with both complexity and uncertainty. There is complexity due to the densely interconnected networks in which decision-actors operate, which span between and across ecological, economic and socio-political domains. There is also uncertainty because what other decision-actors involved in the network are going to do is largely unknown, making difficult to predict whether the choices pay off or not (Rosenhead and Mingers, 2001).

In these complex and uncertain environments, it is very difficult to determine how effective a risk management policy will be. Part of the difficulty resides in the fact that even when a policy is targeted to regulate the behaviour of individual, actors are interdependent in performing their tasks, so any action choice will influence and be influenced by the actions choices of the other actors (Brock and Durlauf 2001).

The governance structures allowing the management of water-related risks have been extensively investigated in the scientific literature. Evidences demonstrated that, in order to be effective, strategies for coping with water-related risks require not only a deep understanding of the main phenomena to be addressed, but also an unprecedented level of cooperation between different levels of institutional government and the private sector. Non-state actors – i.e. corporations, NGOs, community groups – are increasingly involved in responding to climate change and associated risks. This means that the risk management is no longer an exclusive matter for public institutions.

Although, local governments still play a prominent role in leading risk management processes, private and civil society actors are increasingly important. Key actors in the policy process typically fall into four key categories: state actors (governments or related institutions, including local governments), market actors (business and business institutions), scientific actors (including other expert domains such as economics), and civil society, which encompasses the media as well as social movement organizations (Cochran & Teasdale, 2011). Moreover, the boundaries between the public and the private sector are increasingly blurred, with a mutual exchange of roles and responsibilities (Castán Broto & Bulkeley, 2013). Public-private partnerships at different governance levels are quite common in the risk management. These partnerships can be either vertical – that is, involving private and public actors at different governance levels – or horizontal – e.g. partnerships between governments, civil society organizations and private actors.

Governmental institutions condition the way that agents and systems interact to respond to climate stress (Tyler & Moench, 2012). Risk management processes involve the interdependence of agents through their relationships with each other, with the institutions in which they reside (organizational structures), the knowledge they use and the resources based on which they depend (Adger, 2003; Castán Broto & Bulkeley, 2013). Many potential risks related to climate change necessarily involve intervention and planning by the institutional actors, yet risk management strategies are equally dependent on the ability of individuals and communities to act collectively (Adger, 2003). Collective decision making is a central feature in the policy process for risk management (Cochran & Teasdale, 2011).

Thus, the way different actors relate each other play a fundamental role. Trust, information sharing and cooperation, which are at the basis of the collective actions, are developed through the relational network in which the actor are involved. These relationships form the social capital, which is increasingly considered as fundamental in addressing the climate-related risks at urban level and enabling the local adaptation to climate change (Adger, 2003). The social capital is expressed through trust, social norms, obligation and information sharing that characterize the social networks. That is, social networks are considered as crucial embodiment of social capital (Islam and Walkerden, 2014). Strong social networks have been proved to improve collaborative governance processes by facilitating the generation, acquisition and diffusion of different types of knowledge and information (Cunningham et al., 2015). In urban planning for adaptation, as well as for other decision-making processes, interaction among different decision actors are formalized (prescribed) by regulations. Nevertheless, experiences demonstrate the inadequacy of the official protocols to fully describe the complexity of the interactions. Most of the time, the actual networks are far less hierarchical and accounts for informal interactions taking place among decision actors. That is, besides the official interactions, the institutional actors activated personal relationships to gather important information and to perform tasks (Giordano et al., 2017).

The structure of the networks helps determine both the availability of expertise and the potential level of conflicts to which one is exposed in the network. Moreover, the structure of the network, in terms both of the patter of connections and the way in which individuals are distributed across them, alters aggregated outcomes (Siegel, 2003). Finally, the structure of the network of interaction strongly affects the effectiveness of the information sharing processes (Giordano et al., 2017).

Institutional and non-institutional actors who have access to timely, understandable and reliable information are better able to respond to climate threats. Households, enterprises, community organizations and other decision-making agents should have ready access to credible and meaningful information to enable judgments about risk and vulnerability, and to assess adaptation options (Cochran & Teasdale, 2011). Using social networks to engage the community

in climate policy should prove advantageous as the information being disseminated is likely to be trusted and accepted by individuals within the network, prompting individual and collective action (Cunningham et al., 2015). Moreover, the active involvement of stakeholders in developing and implementing climate policies is required by several EU level policies (i.e. Directive 2003/35/EC of the European Parliament and of the Council of 26 May 2003).

Enhancing the information sharing processes within the interaction network in which the different actors are embedded could be not enough for enabling an effective collective action for climate change adaptation. Decision-makers need to cope with uncertainty due to ambiguity in problem understanding. Action choices are not neutral, but commensurate with the perspectives and frames held by the actors making the decisions. The group decision frame explicitly incorporates each member's frame, so it is broader than any member's decision frame (Keeney, 2015). The problem is that when these frames do not overlap or are incompatible, they lead to a situation of ambiguity (Brugnach and Ingram, 2012).

Ambiguity refers to the degree of confusion that exists among actors in a group for attributing different meaning to a problem that is of concern to all (Weick 1995). In a management situation, it indicates that there are discrepancies in the way in which the situation is interpreted. It originates from differences in interests, values, beliefs, background, previous experiences and societal position among the actors (Van den Hoek et al., 2013). Under the presence of ambiguity it may not be clear if a situation is problematic or not, or if there is a problem what the problem is, or whose problem it is, or what actions path should be taken to deal with it (Brugnach et al., 2011; Brugnach and Ingram, 2012 for reviews and details)

In multi-actors setting the presence of ambiguity is unavoidable. This is particularly true in an institutional decision environment, where the different roles played by the decision-actors affect the lens through which they give a meaning to a certain situation. Ambiguity in problem framing may have diverse implications. On the one hand, a diversity in frames can offer opportunities for innovation and the development of creative solutions (Brugnach and Ingram, 2012). From this point of view, a certain degree of ambiguity is desirable to foster the collaborative work needed to enable urban adaptation. On the other hand, the presence of ambiguity can be a source of discrepancies or conflict in a group. When this happens, ambiguity can result in a polarization of viewpoints and the incapacity of a group to create a joint basis for communication and action, conditions that can greatly interfere with the development of collective actions (e.g., Brugnach et al. 2011). The extent to which the lack of shared meaning alters the implementation of a policy is largely dependent on the behavioural repertoires actors use to interact with one another (Donnellon et al. 1986). It has been suggested that divergent frames can still yield organized collective action when the interaction frames (i.e., communication behaviours actors use) are sufficiently aligned (Dewulf et al. 2009). Evidences demonstrate that making the decision actors aware of the existence of ambiguous problem

framing is the key to enable creative and collaborative decision-making processes (e.g. Giordano, Brugnach, & Pluchinotta, 2016).

Figure 1 shows how ambiguity in problem understanding could cause discussions and conflicts in the initial stage of the participatory process, increasing the time required for making the decision. Nevertheless, addressing the ambiguity issues in the early phase of the process has a positive impact on the implementation phase. Contrarily, neglecting the existence of different and equally valid problem framings (unilateral decision-making process) facilitates the identification of the best solution, but conflicts will immediately arise, hampering the implementation phase and/or reducing the measure's effectiveness.

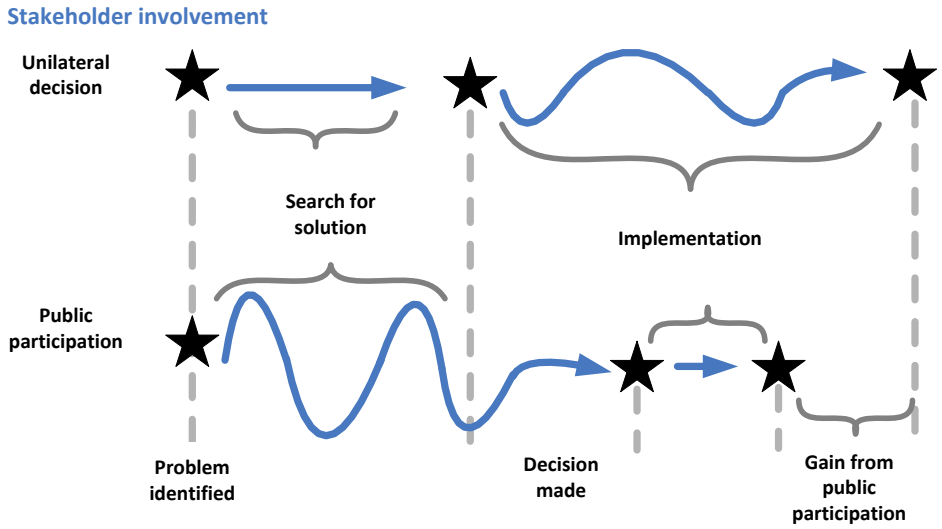

Figure 1. Impacts of the stakeholders' involvement on the decision-making process.

This work aims at investigating to which extend ambiguity in risk perception could hamper the design and implementation of NBS for copying with water-related risks. Moreover, this work aims at enhancing the interaction mechanisms involving the different institutional actors, in order to enable the collaborative decision-making processes for risk management. To this aim, two methodology were sequentially implemented in this work, i.e. Problem Structuring Methods for Ambiguity Analysis, and Social Network Analysis for unravelling the complexity of the interaction networks involving the different stakeholders.

The analysis carried out in this work refer mainly to the institutional actors involved/interested in the risk management process and NBS implementation. Therefore, the term "risk perception" is related to the organizations' perspective, and not to the individuals' one. This was stated

explicitly at the begging of each interview. Therefore, addressing gender issues in risk perception analysis is out of the scope of this work.

2. METHODOLOGY – PROBLEM STRUCTURING METHOD FOR AMBIGUITY ANALYSIS

The implementation of the PSM in this work aims at assessing to what extent divergences in problem framing could also lead to barriers hampering the adoption of risk management measures, and specifically Nature-Based Solutions (NBS). To this aim, PSM were adopted to elicit and structure individual risk perception and, subsequently, Ambiguity analysis was carried out in order to detect potential conflicts due to polarized problem understanding. Moreover, a preliminary assessment of the degree of NBS acceptability was carried out.

PSM are based on the assumption according to which the most demanding and troublesome task in problem solving often consists in defining the nature of the problem, rather than its solutions (Rosenhead and Mingers, 2001). PSMs support the elicitation of the different perceptions of the problematic situation and facilitate the debate in which assumptions about the world are teased out, challenged, tested and discussed (Checkland, 2001). During the debate, participants become aware of each other's perspectives and key interests. The objective of the debate is the establishment of a common understanding, which supports information exchange and co-operation.

PSMs do not aim to create a linear process through which an unstructured problem becomes structured. PSMs aim to identify, confront and integrate different views with respect to a given problem situation (Hommes et al., 2009). PSMs recognize and integrate participants' subjective perspectives, the importance of mutual learning, iterative process design and adaptive decision making. Given the main scope of this work, here we assume that the stakeholders involved in the different phases of the analysis were describing their problem understanding as member of a specific institution, rather than their own personal perspective.

Among the different PSMs, this work focuses on cognitive mapping methodologies, and specifically on Fuzzy Cognitive Mapping. Fuzzy Cognitive Map (FCM) can be considered as a model which is as close as possible to the cognitive representation made by decision makers. Thus the model can be considered as a "mirror" of the causes and effects that are inside the mind of decision makers (Montibeller et al., 2001; Kok, 2009). FCMs can simulate the cause – effect relationships between the main variables in the model. The FCM comprises concepts representing the key elements of the system, joined by directional edges or connections representing causal relationships between concepts. Each edge is assigned a weight which quantifies the strength of the causal relationship between two concepts (Kosko, 1986). The tool is said to be semi-quantitative because the quantification of the variables and connections can be interpreted in relative terms only (Kok, 2009).

FCM is a flexible tool that has been successfully applied in a large number of discipline. The FCM have been largely used to analyze system dynamics in the business domain (e.g. Xirogiannis and Glycas, 2007; Glykas and Xirogiannis, 2004). The FCM are increasingly applied in spatial and environmental planning. Ozesmi and Ozesmi (2004) used FCM to analyze the perceptions about an ecosystem held by people in different stakeholder groups. De Kok et al. (2000) adopted a FCM approach qualitative to integrate social science concepts in a quantitative modeling for water management scenarios development. Xirogiannis et al. (2004) proposed an FCM – based approach to model experts' decision mechanisms in the field of urban area management.

The implementation of FCM to support water-related risk management is based on the analysis of the two main phases of a decision process, i.e. the divergent and the convergent thinking phases (Montibeller et al., 2001). From decision analysis point of view, during the divergent thinking stage, the issue is disclosed, different views are encouraged and proposed, alternatives are generated, objectives are defined and the boundaries of the problem definition are discussed during the debate among the decision makers. Thus, FCM can be useful during divergent thinking phase because it supports creative definition of the problem's characteristics and the identification of alternatives. It can be used to clarify what interests are involved in the discussion and to facilitate the debate. For what concerns the risk management and the role of NBS, FCM can support the divergent thinking phase by making explicit the existence of different concerns and interests related to water-related risks, and to assess to level of social acceptance of NBS.

During the convergent thinking phase, criteria are defined to measure the performances of alternatives on the objectives, data about these performances are gathered, compensations between criteria are stated, alternatives are ranked, and the 'best' alternative is selected and implemented (Montibeller et al., 2001). The convergent thinking phase in this work aimed at reducing the differences among decision-actors' preferences and to get to a consensual definition of suitable risk management measures. To this aim, FCM's potentialities to simulate qualitative decision scenarios were considered as crucial (Kok, 2009). In NAIAD, the convergent thinking phase will be carried out through a series of stakeholders WS in the different demos. This deliverable is mainly focused on the divergent thinking phase.

2.1 The divergent thinking phase: constructing the Fuzzy Cognitive Map and ambiguity analysis

The first phase in the implementation of the FCM to support the water-related risks management was meant to elicit and structure the different stakeholders' risk perception. As already stated, the basic assumption of this work is that different problem understandings could lead to different and potentially conflictual actions for dealing with risks. This, in turn, could

represent a barrier to the design and implementation of NBS. In order to make ambiguity a source of creativity in the development of risk management issues, decision-makers need to be aware of the existence of different, and equally valid, problem understandings.

The first issue to be addressed concerned the selection of the experts to be involved in this phase. In order to minimise the selection bias and the marginalization of stakeholders (Ananda & Herath, 2003; Reed et al., 2009) a top-down stakeholder identification practice, which is referred as ”snowballing” or ”referral sampling”, was implemented (Harrison & Qureshi, 2000; Prell et al., 2008; Reed et al., 2009). The selection process started with the actors mentioned in the official protocol of interaction for risk management, i.e. the decision actors whose main responsibility is to develop strategies and plan for risk management. The preliminary interviews carried out with these agents allowed us to widen the set of stakeholders to be involved (Giordano et al., 2017).

The individual FCM were developed through semi-structured interviews. The interviews aimed at collecting the stakeholders’ perceptions about the cause-effects chains affecting the impacts of water risks in the demo, and the potential solutions. In order to use the results of interviews for the FCM development, a “means-ends” hierarchical approach was adopted in this phase. The interviewees were, thus, required to describe the main water-related risks in the study area, according to their own understanding. Then, they described the primary (direct) and secondary (indirect) impacts of those risks. The main causes of the system vulnerability were also described. Finally, the interviewees were required to describe potential and/or existing strategies to reduce the risks and/or mitigate the impacts. The role of NBS was discussed as well.

The interviews were analyzed in order to detect the keywords in the stakeholders’ argumentation – i.e. the variables in the FCM – and the causal connections among them – i.e. the links in the FCM.

Following Slegers (2008), the interviews were aimed at collecting actors' experiences about both direct and indirect impacts of climate changes. Participants were required to specify elements which can either increase or decrease those impacts. They were also required to specify both the information used to support the selection, implementation and assessment of the actions needed to cope with the risks related to climate changes.

The following figure shows how the stakeholders’ narratives, collected during the interviews, were translated into FCM variables and relationships.

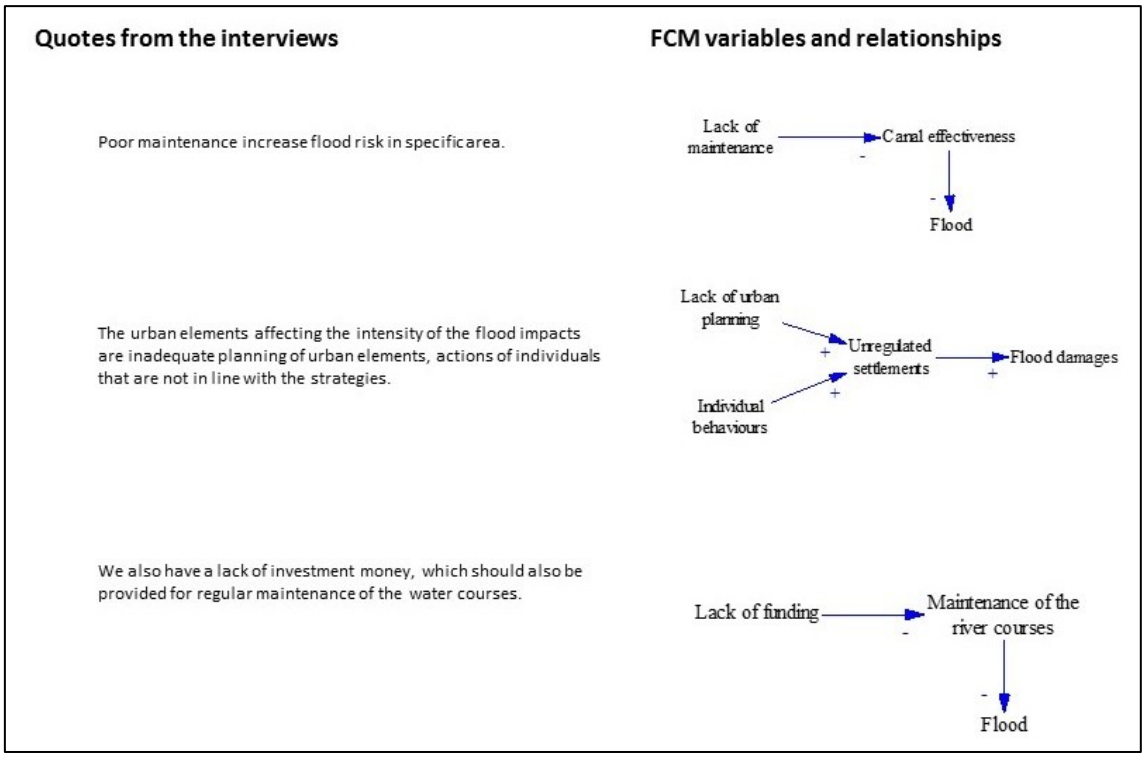

Figure 2. Translating quotes from the stakeholders' interviews into variables and relationships of FCM.

The links (i.e. relationships) in a FCM can be either positive or negative. The existence of a positive link between "A" and "B" means that if A increases then B increases. If the link is negative, then an increase in A implies a decrease in B. Once all the concepts and links were identified, the analysts were required to define the strength of the links accounting for the stakeholders' perception. The strength of a link between two concepts indicates the intensity of the relationship between them, that is to say, how strong is the influence of one concept over the other. The strength can assume values in the interval [-1; 1]. The relationships between variables can be represented in an adjacency matrix. In the FCM, this matrix allows the overall effects of an action on the elements in the map to be inferred qualitatively, as described below.

The FCM developed referring to the stakeholders' interviews were used to infer their main interests and concerns about risk and risk management in the demos. For a more detailed description of the FCM developed in the NAIAD demo, please, refer to the following sections. Two sequential analysis were carried out. Firstly, the FCM were analysed in order to detect the most important elements in the stakeholders' problem understanding, the so called "nub of the issue" (Eden, 2004). Secondly, the FCM capability to simulate qualitative scenarios were used to

assess the expected impacts of climate related information on the stakeholders' problem understanding.

Concerning the first analysis, FCM centrality degree was assessed. The basic assumption in assessing the centrality degree of the variables contained in the FCM is that the more central the variables, the more important the concept is in the stakeholder's perception. Taking into account that the meaning of a variable in a FCM depends on its explanations and consequences (Eden, 2004), the centrality of each concept can be assessed analyzing the complexity of the surrounding perceived causal chains. The following equation was used in this phase of the analysis:

$$CI = td(vi) = od(vi)+id(vi)$$

$od(v_i) = \sum_{k=1}^{N} \bar{a}_{ik}$ Out-degree shows the cumulative weight of connections (aij) exiting the variable, where N is the total number of variables.

$od(v_i) = \sum_{k=1}^{N} \bar{a}_{ik}$ In-degree shows the cumulative weight of variables entering the variable.

The centrality degree was the first element used in this work to identifying the most important element in the stakeholders' problem understandings.

The individual FCM were then used to define the stakeholders' information needs. To this aim, different scenarios were simulated using the individual FCM. The Business-As-Usual scenario (BAU) was simulated running a FCM process ((Kok, 2009) with an initial state vector A0, with all variables set to 0, besides those related to water-related risks.

Table 1. Adjacency matrix and initial state vector A0 for the BAU scenario simulation.

			C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
C1	Rainfall intensity	1,00	**1,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C2	GW flooding	0,00	0,70	**0,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C3	Flood	0,00	1,00	0,00	**0,00**	0,00	0,00	0,70	0,00	-0,70	0,00	0,00	0,00	0,00	0,00
C4	Building and infrastr. damages	0,00	0,00	1,00	0,70	**0,00**	0,30	0,00	0,00	0,00	0,00	-0,30	0,00	0,00	0,00
C5	Flood plain occupation	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,70	0,00	0,00	0,00	0,00	0,00	0,00
C6	Impervious surfaces	0,00	0,00	0,00	0,00	0,00	0,70	**0,00**	0,30	0,00	0,00	0,00	0,00	0,00	0,00
C7	Lack of urban and spatial planning	1,00	0,00	0,00	0,00	0,00	0,00	0,00	**1,00**	0,00	0,00	0,00	0,00	0,00	0,00
C8	Infrastructure effectiveness	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	1,00	0,00	0,00	0,00	1,00
C9	Maintenance intervention	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00	-0,70	0,00
C10	Individual prevention measures	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	0,70	0,00	0,00
C11	Community awareness	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00
C12	Lack of founding	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**1,00**	0,00
C13	Infrastructural intervention	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-1,00	**0,00**

The table 1 shows the list of variables forming the stakeholder's FCM, the initial state vector, and the weight of the connections among the different variables. In order to simulate the BAU scenario, the variables "rainfall intensity", "lack of urban and spatial planning", and "lack of

founding" were activated. That is, their initial state was set to 1. Individual adjacency matrixes were developed for each interviewed stakeholder.

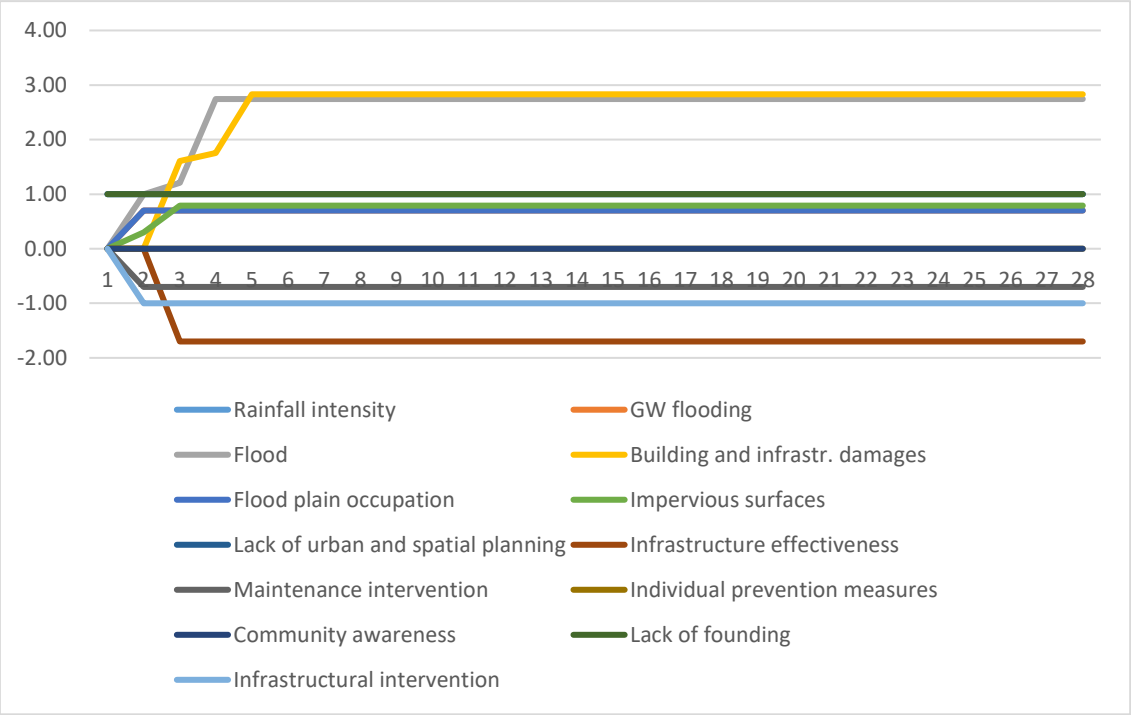

Figure 3. Chart representing the state of the FCM variables in the "BAU" scenario. The x-axis represents the number of vector x matrix iterations before the variables reached a stable state. The y-axis measure the change in the variable state.

The results of the FCM simulations were used to identify the most affected variables according to the stakeholders' mental model. The basic assumption is that the higher the impacts of water-related risk on the variables in the stakeholder's mental model, the more central these issues are in the stakeholders' risk perception.

The degree of change for the most important element in the FCM due to the water-related risks was assessed using the fuzzy linguistic variable shown in figure 4.

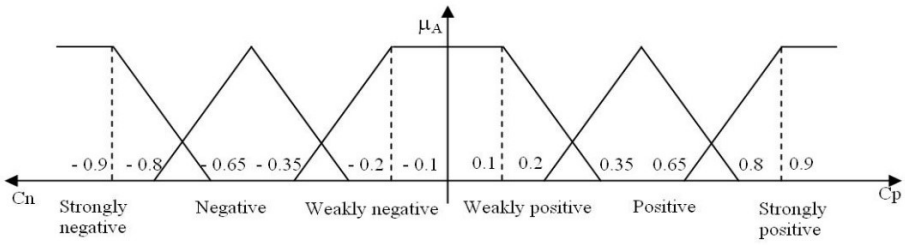

Figure 4. Fuzzy linguistic function representing the risk impact degree.

The most important elements in the stakeholders' risk perception were, hence, detected by aggregating the FCM centrality degree and the impact degree, as shown in the table 2. These elements represent the most important goals to be achieved through the implementation of a risk management measure, according to the stakeholders' risk perception.

Table 2. Aggregation of centrality and impact degree in order to detect the most important elements in the stakeholders' risk perception.

FCM variables	Centrality degree	Impacts degree	Importance degree

The FCM capabilities to simulate risk management scenarios were also used in this work to carry out an *ex-ante* assessment of the NBS social acceptance. To this aim, the values of the most central variables in two different scenarios were assessed and compared, namely the BAU scenario and the NBS-based (characterized by the implementation of NBS) scenario. This comparison allowed us to assess the acceptance degree for each of the involved stakeholders. The more positive is the change in the central variables' due to the implementation of the NBS, and the higher is the acceptance degree.

2.2 The convergent thinking phase: the social FCM and the scenario analysis

The results of the individual problem structuring approach will be used to facilitate the discussion among the different stakeholders and to support the creation of consensus over the most suitable risk management measures and, among those, over the most suitable NBS. To this aim, the individual FCM were augmented and super-imposed in order to obtain the so-called Social FCM (Kok, 2009). The Social FCM will be used to facilitate the discussion among the stakeholders during workshops organized in the different demos. According to the NAID plan of implementation, the WS will be held at end of the first year. Therefore, this phase will be described in the other WP3 deliverables.

3. SOCIAL NETWORK ANALYSIS FOR RISK MANAGEMENT

Decision-making actors do not operate in a vacuum. Social interactions can influence risk perception due to the rapid flow of information and, consequently, it can alter choices. The main scope of this phase is to analyse the way the different stakeholders interact each other an exchange information, knowledge, resources in order to collaborate in the management of water-related risks.

Three kind of networks can be identified in a community of decision agents, i.e. bonding, bridging and linking. Bonding social networks refer to the relations within the same community. Bonding relationships are, broadly speaking, inward looking. They are particularly closed relationships. Bridging social networks connect members of the group to external networks. They could be considered as horizontal relationships with similar entities. Linking relationships are considered as networks of trusting relationships between people who are interacting across explicit, formal or institutionalized power. Linking relationships are vertical relationships. The following figure shows the different kind of social networks influencing the social capital:

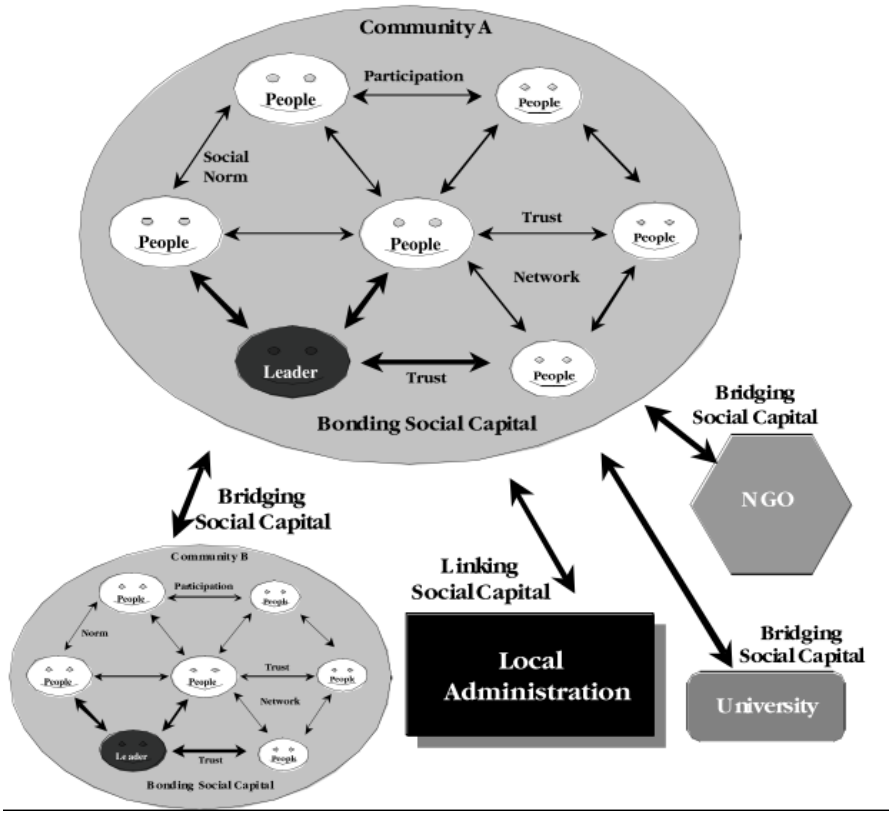

Figure 5. Bonding, bridging and linking social networks.

Most of the relationships in the context of risk management are defined by the official protocol of interactions. Nevertheless, experienced demonstrated that besides the "formal" relationships, informal network of connections is activated in order to make the decision process more effective.

Social network analysis (SNA) can help understanding how and why the actors behave the way they do, through the analysis of structural patterns of relations. Moreover, it provides valuable insights to ambiguity in problem understanding and framing, and how uncertainty is dealt with. The basic assumption behind the role of social network analysis in risk management is that the structural patterns of relations in networks influence the social processes (Borgatti, 2006). Social network mapping can support the identification and analysis of barriers to cooperation and collaboration (Bodin and Crona, 2009).

Networks topologies can be analysed at the node-level focusing on institutions or actors. The centrality of an actor allows analysis of the role she/he can play in the network as a bridge that connects the others. These actors facilitate the flow of knowledge and information within the network. Central actors can be potential agents of change, facilitating the adaptation to emergence situations.

Although the literature on SNA is well developed, there are few examples of SNA application in risk management. Nevertheless, there is consensus on the role that SNA could play in revolutionizing the way organizations and communities prepare and respond to water-related risks. SNA allows to analyse the impacts of information and activities on individuals and the network as a whole for different scenarios and options. In this work, SNA was implemented to map and analyse the dense network of interactions, both formal and informal, affecting the flow of information and the collaborative processes in risk management.

Among the different methods available in the scientific literature for modelling and analysing the social networks (e.g. Borgatti, 2006; Ingold, 2011; Lienert et al., 2013), the Organizational Risk Analysis (ORA) approach has been implemented in this work (Carley, 2002). The underlying assumption in ORA is that an organization could be conceived as a set of interlocked networks connecting entities such agents, knowledge, tasks and resources (Carley, 2005).

In order to implement the ORA approach, we considered the whole set of actors involved in water-related risk management as one heterogeneous organization (Leskens, Brugnach, Hoekstra, & Schuurmans, 2014). The interlocked networks can be represented using the meta-matrix conceptual framework, as shown in the following table 3.

Table 3. Meta-matrix framework showing the connections among the key entities of social network (adapted from (Carley, 2005)).

	Agent	Knowledge	Tasks
Agent	*Social network:* map of the interactions among the different institutional actors in the different risk management phases	*Knowledge network:* identifies the relationships among actors and information (Who does manage which information? Who does own which expertise?)	*Assignment network:* defines the role played by each actor in the risk management.
Knowledge		*Information network:* map the connections among different pieces of knowledge	*Knowledge requirements network:* identifies the information used, or needed, to perform a certain task in the risk management
Tasks			*Dependencies network:* identifies the work flow. (Which tasks are related to which)

The ORA method theorizes that the effectiveness of a social network is not limited to the way the different actors interact with the others. The meta-matrix framework allows to analyse the complexity of the interaction network accounting for the role of knowledge and tasks, and of the interconnections among the key elements – i.e. agent, knowledge and tasks. The Agent x Agent matrix is shown in the table 4.

Table 4. Agent x Agent matrix.

	A_1	A_2	A_3	…	A_n
A_1	0	W_{12}	W_{13}	…	W_{1n}
A_2	W_{21}	0	W_{23}	…	W_{2n}
A_3	W_{31}	W_{32}	0	…	W_{3n}
…	…	…	…	0	…
A_n	W_{n1}	W_{n2}	W_{n3}	…	0

In the previous matrix, W_{ij} represents the strength of the interaction between the agent A_i and the agent A_j, defined referring to the stakeholders' opinion about the importance of the connections during the risk management process. The individual FCMs were also used to define the other matrices. For instance, the individual i-th *Agent x Knowledge* matrix was obtained considering the weights assigned by the i-th actor to the different *agent-information* connections. The *Agent x Knowledge* matrix for the i-th agent is represented in the table 5.

Table 5. Knowledge network matrix for the i-th agent.

	I_1	I_2	I_3	…	I_n
A_1	$K^i{}_{11}$	$K^i{}_{12}$	$K^i{}_{13}$	…	$K^i{}_{1n}$
A_2	$K^i{}_{21}$	$K^i{}_{22}$	$K^i{}_{23}$	…	$K^i{}_{2n}$
A_3	$K^i{}_{31}$	$K^i{}_{32}$	$K^i{}_{33}$	…	$K^i{}_{3n}$
…	…	…	…	…	…
A_n	$K^i{}_{n1}$	$K^i{}_{n2}$	$K^i{}_{n3}$	…	$K^i{}_{nn}$

The overall *Agent x Knowledge* matrix was obtained as the sum of the individual matrices. Similar processes were implemented to develop the *Agent x Tasks*, *Knowledge x Knowledge*, *Knowledge x Tasks* and *Tasks x Task* matrices.

The interviews were used to define the weight for each agent-task connection. That is, Y_{11} represents the degree of importance of the task T_1 for the agent A_1. Fuzzy linguistic variables were used to this aim. If the actor did not carried out a specific task, the weight was set to 0. Finally, the *Knowledge x Task* matrix was developed accounting for the perceived importance of the information for performing the tasks.

The maps of the network were used to analyse and unravel the complexity of interactions, allowing the identification of the key elements in the network and the main vulnerabilities. To this aim, graph theory measures were implemented. Table 6 describes the measures adopted for the identification of the key actors, their definition according to the graph theory and the meaning in risk management. For a detailed description of the graph theory measures for the analysis of the networks, a reader could refer to (Freeman, 1978; Carley et al., 2007).

Table 6. Graph Theory measures for key elements detection.

Network	Network measure	Assessment	Meaning in Urban adaptation
Agent x Agent	Total degree Centrality	Those who are ranked high on this metrics have more connections to others in the same network.	Individuals or organizations who are 'in the know' are those who are linked to many others and so, by virtue of their position have access to the ideas, thoughts, and beliefs of many others.
	Betweenness centrality	The betweenness centrality of node v in a network is defined as: across all node pairs that have a shortest path containing v, the percentage that pass through v.	Individuals or organizations that are potentially influential are positioned to broker connections between groups and to bring to bear the influence of one group on another or serve as a gatekeeper between groups.
Agent x Knowledge	Most knowledge	Assess the number of links between a certain agent and the different pieces of knowledge in the network.	An agent with a high value of most knowledge has access to a great variety of knowledge to be used in case of risk.
Agent x Task	Most task	Assess the number of links between a certain agent and the different task that need to be carried out.	An agent with a high degree of most task plays a crucial role in the network due to her/his capability in performing different tasks.
Knowledge x Knowledge	Total degree of centrality	It calculates the importance of a certain piece of information according to the number of connected links.	The most central pieces of knowledge are those whose availability is crucial to make the other pieces of knowledge accessible.
	Betweennes centrality	The Betweenness Centrality of node v in a network is defined as: across all node pairs that have a shortest path containing v, the percentage that pass through v.	The betweennes centrality measure allows us to identify the information that could facilitate the process of information sharing.
Knowledge x Task	Most task	Assess the number of links between a certain piece of knowledge and the different task that need to be carried out.	The pieces of knowledge with a high value for this measure are fundamental for the effectiveness of the network, since without

			them a high number of tasks will be not carried out.
Task x Task	Total degree of centrality	It analyses the complexity of the connections within the task X task network.	Tasks with high degree of centrality are those that have to be carried out in order to allow the executions of the other tasks.

Different measures are mentioned in the scientific literature for the assessment of the network vulnerability, that is, those elements that could lead to failures of the network, lower performance, reduced adaptability, reduced information gathering, etc. (e.g. Carley, 2005). Considering the complexity of the emergency network, in this work the vulnerability elements were identified though the combination of different measures, as described in the table 7.

Table 7. Measures for the detection and analysis of key vulnerability in the urban planning and CCA network.

Network	Network measures	Meaning in emergency management
Agent x Agent **Agent x Knowledge**	Total centrality degree Most knowledge	An actor with a high degree of centrality and a low most knowledge degree represents a vulnerability because, although she/he a central position in the network, she/he has a limited capability to enable information sharing.
Agent x Agent **Agent x Knowledge**	Betweennes centrality Most knowledge	An actor with a high degree of most knowledge and a low betweennes degree represents a vulnerability because she/he is not capable to share with the others the pieces of knowledge she/he has access to.
Agent x Agent **Agent x Task**	Total centrality degree Most task	An actor with a high degree of most task and a low centrality degree represents a vulnerability because, although she/he is required to carry out important tasks, she/he is quite isolated and cannot be supported by the others.
Agent x Knowledge **Knowledge x Task**	Most knowledge Most task	A piece of knowledge poorly shared within the network (low most knowledge) represents a vulnerability if its access is crucial to carry out important task (high most task).
Agent x Knowledge **Knowledge x Knowledge**	Most knowledge Closeness centrality	A piece of knowledge with a high degree of closeness but poorly shared (low degree of most knowledge) represents a vulnerability since it

		could hamper the process of information sharing.
Agent x Task **Task x Task**	Most task Centrality degree	A task with a high centrality degree and with low ost task degree represents a vulnerability because, although its importance, there is no, or very limited cooperation to guarantee its effectiveness.

4. RESULTS – RISK PERCEPTION AND NBS: HINTS FROM SOME OF NAIAD DEMO

The above described methodology for eliciting and structuring stakeholders' risk perception was implemented in several NAIAD demos. Unfortunately, due to time constraints, not all demo leaders have been capable to send us the results of the risk perception elicitation phase. Therefore, this deliverable describes the results of three of the NAIAD demo, namely: Ljubljana, Medina del Campo and the Lower Danube demos. The analysis of the results coming from these demos allowed us to get some hints about the role of risk perception in hampering/enabling the development and implementation of risk management measures.

4.1 The Ljubljana demo

The following institutional actors were involved in the first round of interviews:

Table 8. Institutional actors involved in the first round of interviews.

INSTITUTION	ROLE
CIPV Civil initiative for flood protection of SW part of Ljublajna	They rescue the population in case of emergency and provide an information and prevention activities about flood risk in coordination with governmental organizations
DRSV Slovenian water Agency Sector for development and planning	They participate in the establishment of emergency urban plans as the National Water Management Plan, some parts of the Flood Risk Reduction Plan and some parts of the Water Rehabilitation Plan
MKGP Ministry for agriculture forestry and flood of the Republic of Slovenia	They provide a contribution to build all national plans and strategies in which agricultural areas are included and establish wet retention reservoirs, especially in relation to irrigation of farm land
MOL nat Municipality of Ljubljana, Department for nature conservation	Participating in approving of any plans that affect good state of ecosystems

MOL Civ Municipality of Ljubljana - Department for civil protection and disaster relief	They coordinates and connects the other departments within the Municipality of Ljubljana
MOL Urb Municipality of Ljubljana - Department for Spatial Planning	They prepare strategic plans at urban level and are involved in the preparation of the National spatial plan
MOP Od The ministry of environment and spatial planning – Water and investments directorate – Sector for natural disaster rehabilitation	They prepare a Program to reduce the impacts of natural disaster
MOP Var Slovenian Ministry for environment and spatial planning, Sector for nature protection	They are directly responsible for the preparation of the National Water Management Plan and of the National Plan for Reducing Flood Risk as per the Floods Directive and the national Plan for Management of the Marine Environment
RD Fishing Club Dolomiti	They are directly responsible for the Fish Management Plans, prepared in coordination with the Fishing Club and The Fisheries Research Institute (FRIS).
URSZR Administration for civil protection and disaster relief	They operates at the regional level to regulate and implement protection against natural disasters on the area of 32 municipalities
ZRSV Institute of the Republic of Slovenia for Nature Conservation	They are integrated in Water Management System and for the Flood Risks Reduction Plan at National level
ZZRS Fisheries Research Institute of Slovenia	At the national level they are responsible and included in the process of acquiring permits for interventions in streams for all Slovenia; at Strategic level, they are involved in the preparation of Flood Risks Reduction Plan

Unfortunately, we weren't capable to involve other actors in the knowledge elicitation phase. Nevertheless, information were collected concerning the other institutional actors, as described further in the text.

A round of semi-structured interviews was carried out, aiming at collecting the individual perception of the main water-related risk in the local area, the potential impacts – both direct

and indirect – the risk management measures strategies and, finally, the potential role of risk information. The interviewees were also required to provide information about the flow of water-related information among the different institutional and non-institutional actors. The latter data were used for the social network analysis.

Following the FCM methodology, the results of the interviews were analysed in order to identify the keywords in the stakeholders' argumentation, and to define the perceived cause-effects links connecting the different keywords (variables) and their strength. FCM were developed for each of the interviewed actors.

The figure 6 (a and b) shows two examples of the FCM developed using the Ljubljana interviews.

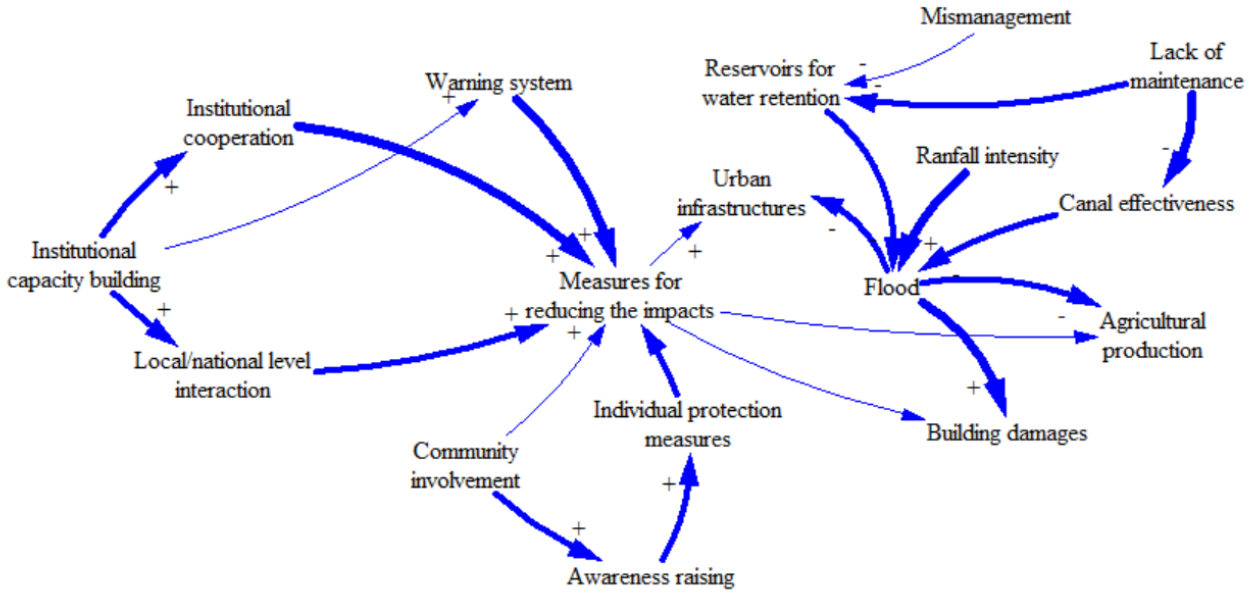

Figure 6(a). FCM representing the problem understanding of the Administration for civil protection and disaster relief.

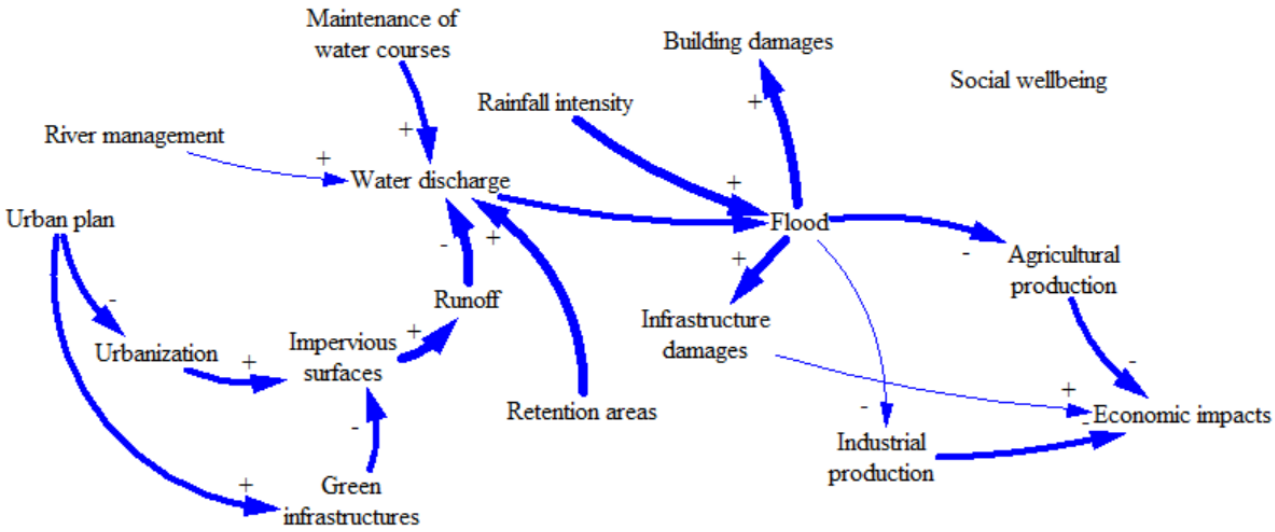

Figure 6(b). FCM representing the problem understanding of the Municipality of Ljubljana - Department for Spatial Planning.

The centrality degree measure was implemented in order to identify the key elements in the stakeholders' problem understanding. The following table summarizes the results of the centrality analysis for the interviewed stakeholders.

Table 9. Main elements in the stakeholders' problem understanding (centrality degree).

Decision actor	Type of variable	Variable	Centrality degree (value)	Centrality degree (index)
Civil initiative for flood protection of SW part of Ljubljana	Vulnerability	Lack of funding	1,56	Medium
		Infrastructure effectiveness	2,42	Medium
		Urbanization of flood plain	2,33	Medium
		People awareness	0,86	Low
	Primary impacts	Building damages	3,23	High
	Secondary impacts	Economic losses	1,63	Medium
Slovenian water Agency - Sector for	Vulnerability	Lack of spatial planning	1,64	Medium
		People awareness	3,44	High
	Primary impacts	Agricultural productivity	1,56	Medium

development and planning		Building damages	0,81	Low
		State of the ecosystem	1,56	Medium
	Secondary impacts	Social vulnerability	0,72	Low
		Water distribution	0,86	Low
Ministry for agriculture, forestry and food of the Republic of Slovenia	Vulnerability	Lack of urban regulation	2,21	Medium
	Primary impacts	Agricultural productivity	1,23	Low
		Building damages	2,08	Medium
		Green areas quality	0,61	Low
	Secondary impacts	Economic losses	2,25	Medium
		State of the ecosystem	1,34	Low
Municipality of Ljubljana, Department for nature conservation	Vulnerability	Urbanization of flood plain	2,15	Medium
		Lack of legislation	1,72	Medium
		Urban plan effectiveness	2,82	High
	Primary impacts	State of the ecosystem	1,54	Medium
		Building damages	1,84	Medium
	Secondary impacts	Community safety	1,60	Medium
Municipality of Ljubljana - Department for civil protection and disaster relief	Vulnerability	Flood plain urbanization	1,31	Low
		People awareness	0,42	Low
	Primary impacts	Building damages	1,59	Medium
		Infrastructure effectiveness	2,21	Medium
		Ecosystem quality	0,42	Low
	Secondary impacts	Transportation costs	1,20	Low
		Economic losses	0,71	Low
Municipality of Ljubljana - Department for Spatial Planning	Vulnerability	Lack of urban regulation	1,67	Medium
		People awareness	0,69	Low
	Primary impacts	Agricultural productivity	0,89	Low
		Building damages	1,00	Low
		Infrastructure effectiveness	3,00	High
	Secondary impacts	Economic losses	2,13	Medium
		Plan effectiveness	2,56	High
The ministry of environment and spatial planning – Water and investments directorate –	Vulnerability	Urbanization of flood plain	2,89	High
		Lack of institutional cooperation	1,76	Medium
		Lack of maintenance of green areas	0,89	Low
	Primary impacts	Infrastructure effectiveness	1,34	Low
		Industrial sector	0,89	Low
		Transportation system	1,23	Low

Sector for natural disaster rehabilitation		Agricultural productivity	1,78	Medium
	Secondary impacts	Urban security	1,56	Medium
		Community safety	2,21	Medium
		Recovery costs	1,45	Low
Fishing Club Dolomiti	Vulnerability	Lack of control	1,53	Medium
		Unregulated infrastructures Development	1,31	Low
		Illegal waste disposal	0,64	Low
	Primary impacts	Building damages	0,33	Low
		Ecosystem quality	0,58	Low
		Industrial sector	0,11	Low
	Secondary impacts	Fish population	0,11	Low
Administration for civil protection and disaster relief	Vulnerability	Mismanagement of the territory	0,11	Low
		Lack of maintenance of green areas	0,7	Low
		People awareness	0,42	Low
	Primary impacts	Urban infrastructures	0,42	Low
		Agricultural productivity	1,2	Low
		Building damages	1,11	Low
	Secondary impacts	Community safety	0,72	Low
Institute of the Republic of Slovenia for Nature Conservation	Vulnerability	Lack of funding	2,25	Medium
		Lack of law enforcement	0,78	Low
		People awareness	1,6	Medium
	Primary impacts	Infrastructure effectiveness	1,52	Medium
		Building damages	1,03	Low
	Secondary impacts	State of the riverbank vegetation	1,5	Medium
		State of the ecosystem	0,86	Low

The individual FCM were also used to identify the main elements affected by flood according to the stakeholders' risk perception. To this aim, the FCM were simulated activating the variable "rainfall intensity" in the FCM initial state vector. Figure 7(a) and (b) show the results of the FCM simulation for two of the interviewed stakeholders.

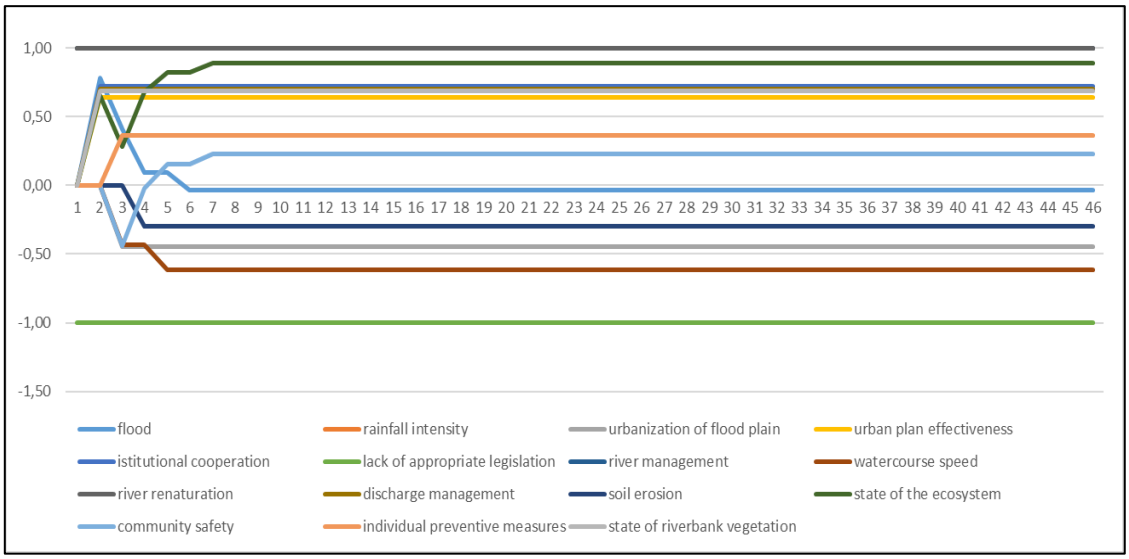

Figure 7(a). Flood impacts on the FCM of Municipality of Ljubljana, Department for nature conservation.

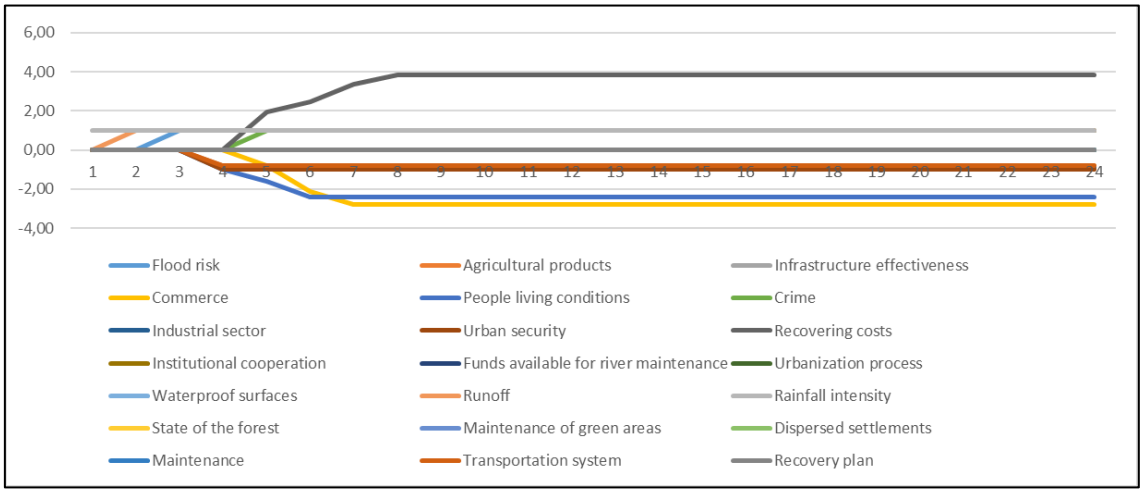

Figure 7(b). Flood impacts on the FCM of The ministry of environment and spatial planning.

These two graphs shows the expected change in the state of the system variables in case of flood, accounting for the cause-effect chains perceived by the stakeholders. The flood impacts was assessed considering the state of the variables at the steady state (Kok, 2009).

The degree of impacts was then assessed normalizing the value of the variables in the interval [-1, 1] and using the fuzzy linguistic function showed in figure 4. The aggregation between the

centrality degree and the impact degree allowed us to identify the most important elements in each stakeholder's risk perception. Table 10 shows the results of the analysis for the Department for nature conservation of the Ljubljana municipality.

Table 10. Aggregation of the centrality degree and the impacts degree.

Variable	Centrality degree	Impacts degree	Importance degree
Urbanization of flood plain	Medium	Weakly negative	Medium
Lack of legislation	Medium	Weakly positive	Medium
Urban plan effectiveness	High	Negative	High
State of the ecosystem	Medium	Negative	High
Building damages	Medium	Weakly negative	High
Community safety	Medium	Negative	Medium

This table shows the three most important elements in the stakeholders' risk perception, i.e. "Urban plan effectiveness", "State of the ecosystem", and the "Community safety". Table 11 shows the importance degree for the stakeholders involved in the Slovenian demo.

Table 11. Identification of the most important elements in the stakeholders' risk perception.

Decision actor	Variable	Centrality degree (index)	Impacts degree	Importance degree
Civil initiative for flood protection of SW part of Ljubljana	Lack of funding	Medium	Weakly negative	Medium
	Infrastructure effectiveness	Medium	Negative	High
	Urbanization of flood plain	Medium	Weakly positive	Medium
	People awareness	Low	Weakly positive	Low
	Building damages	High	Highly negative	High
	Economic losses	Medium	Negative	High
Slovenian water Agency -	Lack of spatial planning	Medium	Weakly negative	Medium
	People awareness	High	Negative	High

Sector for development and planning	Agricultural productivity	Medium	Weakly negative	Medium
	Building damages	Low	Negative	Medium
	State of the ecosystem	Medium	Negative	High
	Social vulnerability	Low	Weakly negative	Low
	Water distribution	Low	Weakly negative	Low
Ministry for agriculture, forestry and food of the Republic of Slovenia	Lack of urban regulation	Medium	Negative	High
	Agricultural productivity	Low	Weakly negative	Low
	Building damages	Medium	Negative	High
	Green areas quality	Low	Weakly negative	Low
	Economic losses	Medium	Negative	High
	State of the ecosystem	Low	Negative	Medium
Municipality of Ljubljana, Department for nature conservation	Urbanization of flood plain	Medium	Weakly negative	Medium
	Lack of legislation	Medium	Weakly positive	Medium
	Urban plan effectiveness	High	Negative	High
	State of the ecosystem	Medium	Negative	High
	Building damages	Medium	Weakly negative	High
	Community safety	Medium	Negative	Medium
Municipality of Ljubljana - Department for civil protection and disaster relief	Flood plain urbanization	Low	Weakly negative	Low
	People awareness	Low	Negative	Medium
	Building damages	Medium	Negative	High
	Infrastructure effectiveness	Medium	Negative	High
	Ecosystem quality	Low	Weakly negative	Low
	Transportation costs	Low	Negative	Medium
	Economic losses	Low	Negative	Medium
Municipality of Ljubljana - Department for Spatial Planning	Lack of urban regulation	Medium	Weakly negative	Medium
	People awareness	Low	Weakly negative	Low
	Agricultural productivity	Low	Negative	Medium
	Building damages	Low	Negative	Medium

	Infrastructure effectiveness	High	Negative	High
	Economic losses	Medium	Negative	High
	Plan effectiveness	High	Negative	High
The ministry of environment and spatial planning – Water and investments directorate – Sector for natural disaster rehabilitation	Urbanization of flood plain	High	Weakly negative	Medium
	Lack of institutional cooperation	Medium	Negative	High
	Lack of maintenance of green areas	Low	Weakly negative	Low
	Infrastructure effectiveness	Low	Negative	Medium
	Industrial sector	Low	Weakly negative	Low
	Transportation system	Low	Negative	Medium
	Agricultural productivity	Medium	Negative	High
	Urban security	Medium	Weakly negative	Medium
	Community safety	Medium	Negative	High
	Recovery costs	Low	Weakly negative	Low
Fishing Club Dolomiti	Lack of control	Medium	Weakly negative	Medium
	Unregulated infrastructures Development	Low	Weakly negative	Low
	Illegal waste disposal	Low	Weakly negative	Low
	Building damages	Low	Negative	Medium
	Ecosystem quality	Low	Negative	Medium
	Industrial sector	Low	Weakly negative	Low
	Fish population	Low	Negative	Medium
Administration for civil protection and disaster relief	Mismanagement of the territory	Low	Negative	Medium
	Lack of maintenance of green areas	Low	Weakly negative	Low
	People awareness	Low	Weakly positive	Low
	Urban infrastructures	Low	Negative	Medium
	Agricultural productivity	Low	Negative	Medium
	Building damages	Low	Negative	Medium

	Community safety	Low	Negative	Medium
Institute of the Republic of Slovenia for Nature Conservation	Lack of funding	Medium	Weakly positive	Medium
	Lack of law enforcement	Low	Weakly negative	Low
	People awareness	Medium	Weakly negative	Medium
	Infrastructure effectiveness	Medium	Negative	High
	Building damages	Low	Negative	Medium
	State of the riverbank vegetation	Medium	Negative	High
	State of the ecosystem	Low	Negative	Medium

The aggregation between the centrality degree and the impact degree allowed us to identify the key variables for each stakeholders and, thus, to analyse similarities and differences. Specifically, table 11 that most of the stakeholders considered the low level of implementation of the urban and spatial planning as one of the main elements affecting the system vulnerability to flood. According to the stakeholders' problem understanding, this leaded to an increase of the urbanization of the flood plain and, consequently, to an increase of the flood risk. Besides, the lack of institutional cooperation and community awareness seem to reduce the capability of the system to design and implement effective risk management measures. Concerning the perceived impacts, table 11 shows a high level of consensus about the variables "Building damages", "Infrastructure damages" and "Agricultural productivity". Only few stakeholders mentioned the state of the river ecosystem as an important element affected by flood.

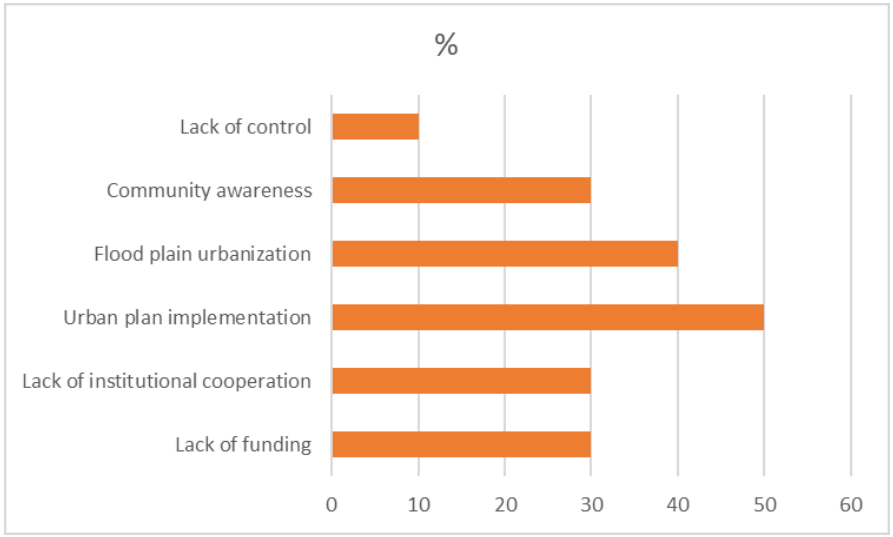

Figure 8(a). Percentage of stakeholders perceiving the elements of vulnerability as important (medium and high importance degree).

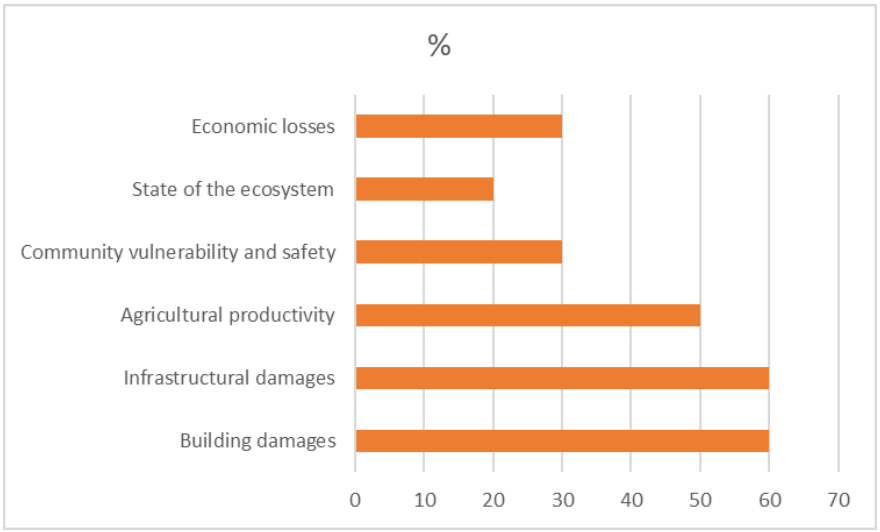

Figure 8(b). Percentage of stakeholders perceiving the impacts as important (medium and high importance degree).

As described previously, the centrality analysis was used to assess the acceptability degree of the NBS, accounting for the stakeholders' risk perception. The basic assumption here is that the more positive the NBS impact on the stakeholders' risk perception, and the higher the acceptability degree. To this aim, the FCM were used to compare the BAU scenario with the one characterized by the implementation of the NBS – e.g. activating the variable "green

infrastructures" and "retention areas" in the Dept. of Spatial Planning FCM. Figure 9 shows the state of the variables in the two scenarios.

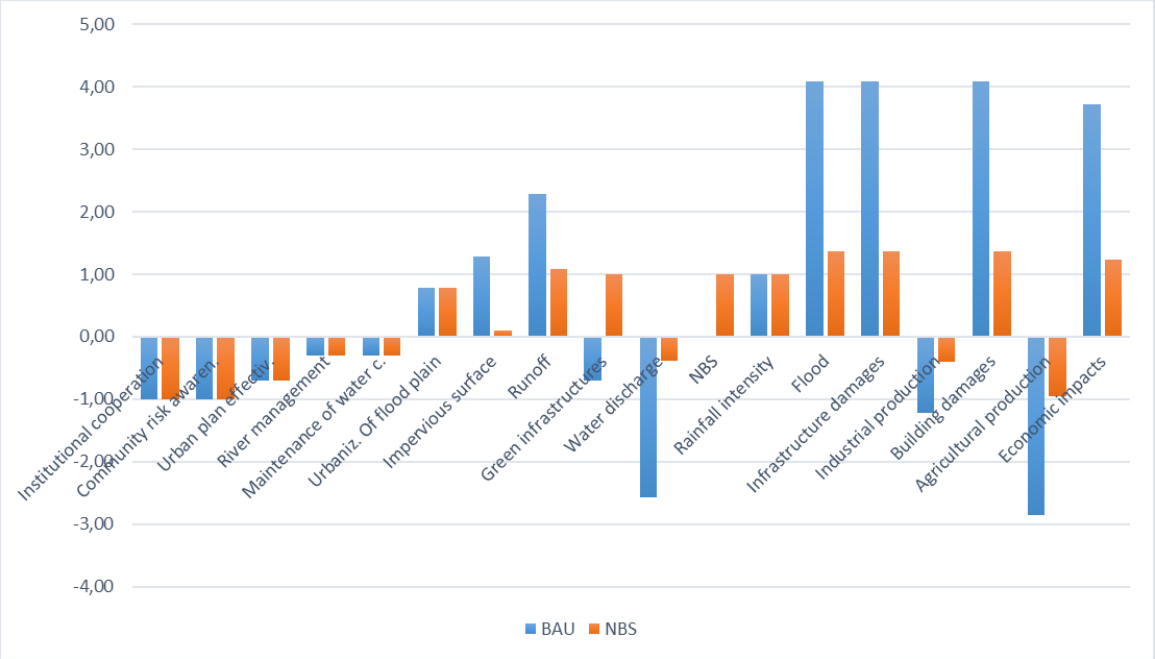

Figure 9. Impact of NBS implementation on the Dept. of Spatial Planning risk perception.

According to the results of the FCM simulation, the NBS can be considered "acceptable" by this stakeholder, since NBS implementation provokes a positive change in most of the central variables – i.e. reduction of infrastructure damages, reduction of building damages and economic losses. Figure 10 shows the results of the acceptability analysis for the Department for civil protection and disaster relief.

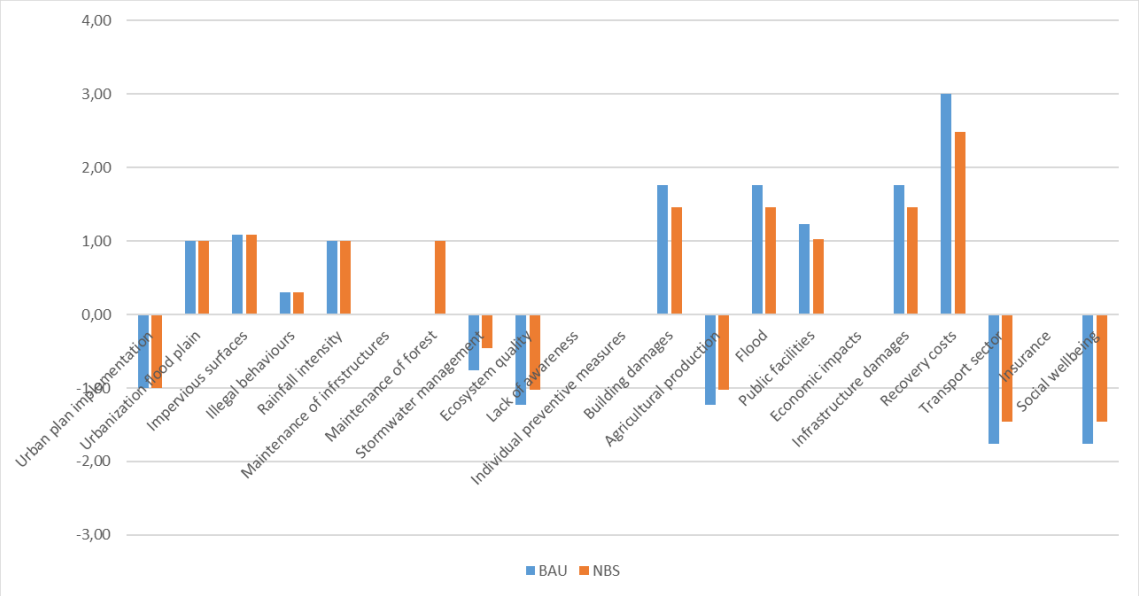

Figure 10. Impact of NBS implementation on the Dept. of Civil Protection and Disaster Relief.

In this case, the acceptability degree is pretty low because the implementation of NBS does not provoke evident positive impacts on the most central variables in the stakeholder's risk perception. This is mainly due to perceived importance of other actions – i.e. "maintenance of infrastructures" and "individual prevention measures" – compared to the NBS.

Table 12. Shows the results of the acceptability evaluation for the Ljubljana demo stakeholders.

Decision actor	Acceptability degree	Main barrier to NBS effectiveness
Civil initiative for flood protection of SW part of Ljubljana	Medium	Low level of risk awareness in the community
		Low level of implementation of urban plan
Slovenian water Agency - Sector for development and planning	Medium	Low level of implementation of urban plan
Ministry for agriculture, forestry and food of the Republic of Slovenia	High	Low level of implementation of urban plan

Municipality of Ljubljana, Department for nature conservation	Medium	Low level of implementation of urban plan
Municipality of Ljubljana - Department for civil protection and disaster relief	Low	Low level of risk awareness in the community
		Low impact on infrastructure effectiveness
Municipality of Ljubljana - Department for Spatial Planning	High	No barrier
The ministry of environment and spatial planning – Water and investments directorate – Sector for natural disaster rehabilitation	Low	Lack of institutional cooperation
Fishing Club Dolomiti	Low	Lack of territory control
		Low level of plan implementation
Administration for civil protection and disaster relief	Medium	Lack of territory control
		Low level of risk awareness in the community
Institute of the Republic of Slovenia for Nature Conservation	High	Lack of funding
		Low level of risk awareness in the community

4.2 The Medina del Campo Demo

The following institutional actors were involved in the first round of interviews:

Table 13. Institutional actors involved in the first round of interviews.

Organization	Role
Avila government	Supports municipalities in water supply and environmental issues.
Regional Environ. Council	Responsible for regional planning in natural spaces, environmental quality, sustainable development strategies, at regional level.
Medina del Campo Municipality	City planning, water supply, flood management support.

Alhondiga (cultural association)	Cultural and environmental association of the civil society in the municipality of Arévalo.
ACUAES (public company for infrastructures)	Managing the dam that provides surface water to farmers in the DEMO area.
Union de Campesinos	Farmer´s Union.
Salamanca university	Research in the region related to water risks.

The methodology described in previous sections was then implemented in order to elicit and structure individual risk perception, as shown in figure 11(a) and (b).

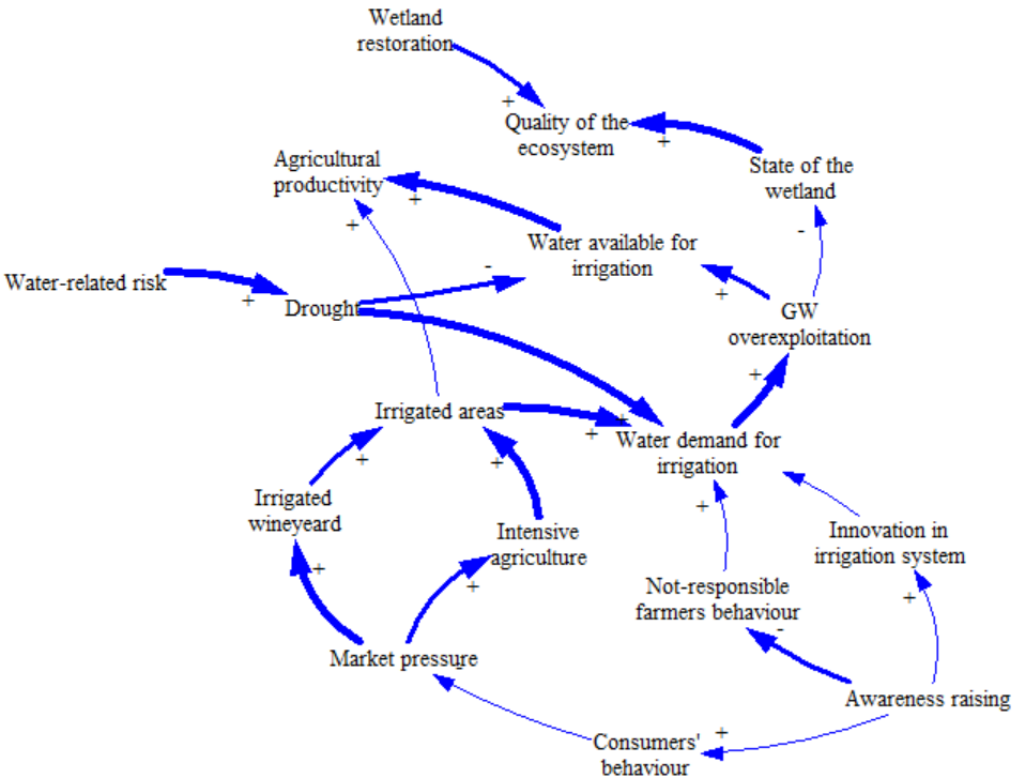

Figure 11(a). Medina City Council FCM.

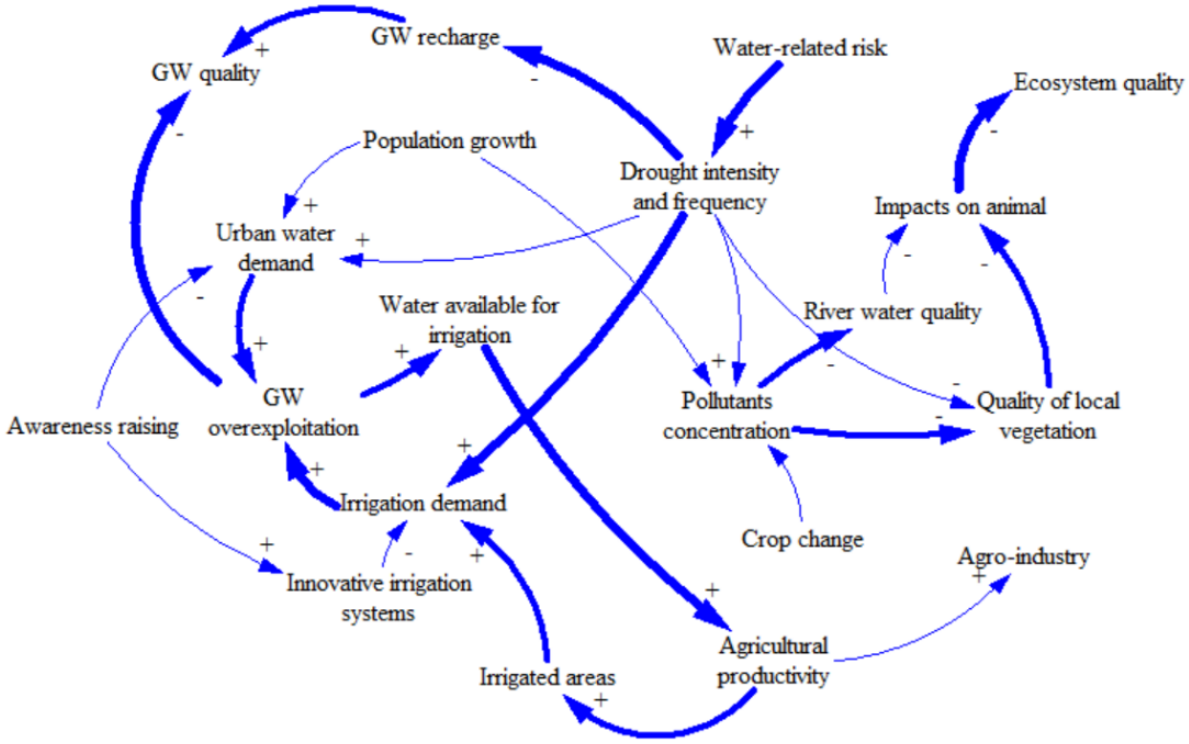

Figure 11(b). Regional **Council** FCM.

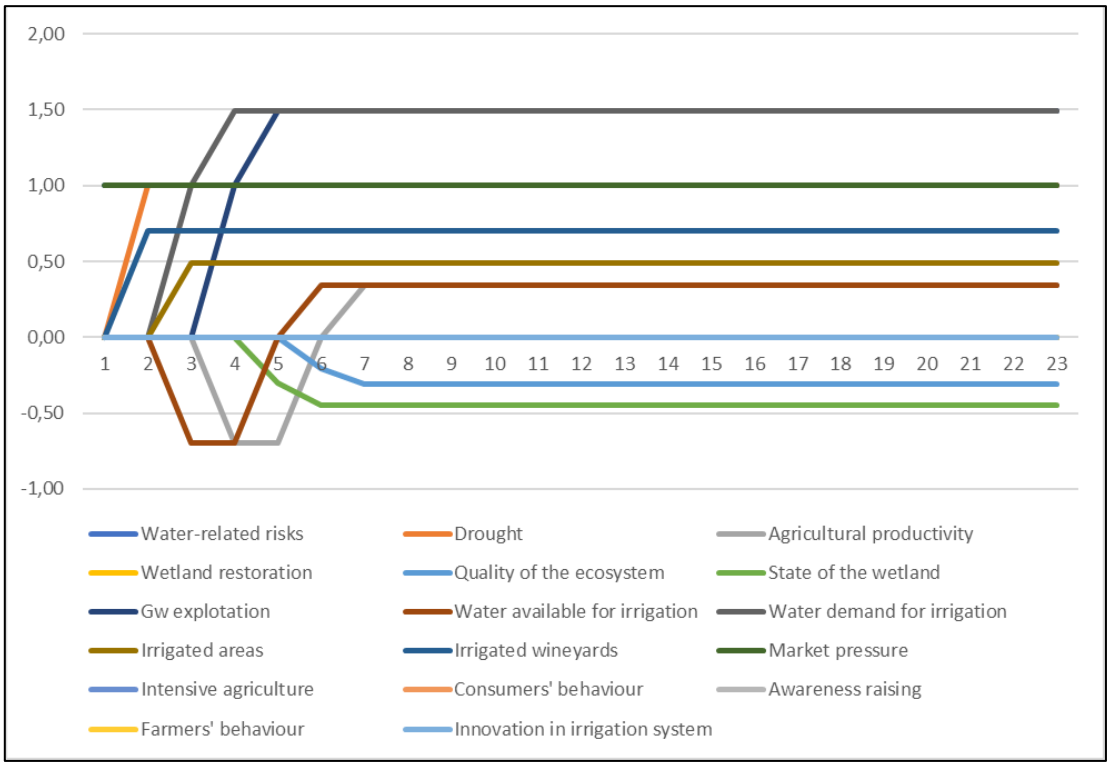

Figure 12. Medina City Council FCM simulation.

The developed FCM have been analysed in order to assess the centrality degree of the different variables. Moreover, FCM were simulated in order to assess the impacts of drought on the elements of the stakeholders' risk perception. Figure 12 shows the results of the FCM simulation for the regional council.

Table 14. Main elements affecting the stakeholders' risk perception in the Medina del Campo demo.

Decision actor	Type of variable	Variable	Centrality degree (index)	Impacts degree	Importance degree
Avila government	Vulnerability	Lack of institutional cooperation	Medium	Negative	Medium
		Lack of public funds	Low	Negative	Medium
	Primary impacts	Pollutants concentration	High	Negative	High
		GW quality	High	Highly negative	High

		Water supply	Medium	Weakly negative	Medium
	Secondary impacts	Agricultural productivity	High	Negative	High
		Community health	Medium	Weakly negative	Medium
		Local development	High	Weakly negative	Medium
Regional Environ. Council	Vulnerability	Farmers' behaviour (crop selection)	Low	Weakly negative	Low
		Limited innovation in irrigation	Medium	Weakly negative	Medium
		Lack of awareness	Medium	Negative	High
	Primary impacts	Water availability	High	Negative	High
		Pollutants concentration	High	Negative	High
		Agricultural productivity	Medium	Highly negative	High
		GW exploitation	High	Highly negative	High
		GW quality	High	Highly negative	High
	Secondary impacts	River water quality	Low	Negative	Medium
		Ecosystem quality	Low	Negative	Medium
Medina del Campo Munic.	Vulnerability	Intensive agriculture	Medium	Weakly negative	Medium
		Farmers' behaviour (crop selection)	Medium	Weakly negative	Medium
		Lack of awareness	Low	Negative	Medium
		Limited innovation in irrigation	Low	Weakly negative	Low
	Primary impacts	GW exploitation	High	Highly negative	High
		Water availability	High	Negative	High
		Agricultural productivity	High	Negative	High
	Secondary impacts	State of the wetland	Low	Negative	Medium
		Quality of the ecosystem	Low	Weakly negative	Low
Alhondiga (cultural association)	Vulnerability	Deforestation	Medium	Negative	High
		Illegal behaviours	High	Highly negative	High

		Lack of plan implementation	Medium	Weakly negative	Medium
		Soil consumption	Low	Weakly negative	Low
	Primary impacts	Soil erosion	Medium	Negative	High
		Infrastructure damages	Low	Weakly negative	Low
		Pollutants concentration	Medium	Negative	High
		GW level reduction	High	Highly negative	High
	Secondary impacts	Community wellbeing	Low	Negative	Medium
		Loss of biodiversity	Medium	Negative	High
		Agricultural productivity	Low	Negative	Medium
ACUAES	Vulnerability	Lack of funds	High	Negative	High
		Inadequacy of water supply system	High	Highly negative	High
	Primary impacts	Water availability	Medium	Highly negative	High
		Infrastructural development	High	Weakly negative	Medium
		Agricultural productivity	Low	Negative	Medium
		Water quality	Medium	Weakly negative	Medium
	Secondary impacts	Community wellbeing	Medium	Negative	High
		State of the ecosystem	Low	Weakly negative	Low
Union de Campesinos	Vulnerability	Lack of confidence	High	Negative	High
		Limited innovation in irrigation	Medium	Negative	High
		Lack of maintenance	High	Weakly negative	Medium
		Mismanagement of water infrastructures.	High	Negative	Medium
	Primary impacts	Water supply for irrigation	High	Highly negative	High
		Agricultural productivity	Medium	Negative	High
		GW level reduction	Medium	Negative	High
		Community wellbeing	Medium	Negative	High

	Secondary impacts	Local development and migration	Medium	Weakly negative	Medium
Salamanca university	Vulnerability	Mismanagement of water resources	Medium	Weakly negative	Medium
		Irrigation system effectiveness	Low	Negative	Medium
		Infrastructural development	Low	Weakly negative	Low
		Lack of policy guidelines	Medium	Negative	High
	Primary impacts	GW level reduction	High	Highly negative	High
		Pollutants concentration	High	Highly negative	High
		Water quality	Medium	Weakly negative	Medium
		Agricultural productivity	Medium	Negative	High
	Secondary impacts	State of the ecosystem	High	Negative	High
		Water availability	Low	Weakly negative	Low
		Community wellbeing	Low	Weakly negative	Low
		Water management costs	Medium	Negative	Medium

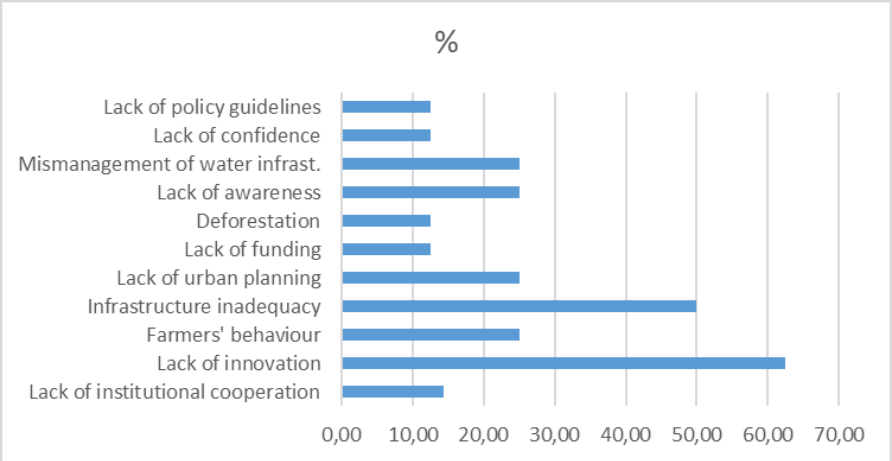

Figure 13(a). Percentage of stakeholders perceiving the elements of vulnerability as important (medium and high importance degree).

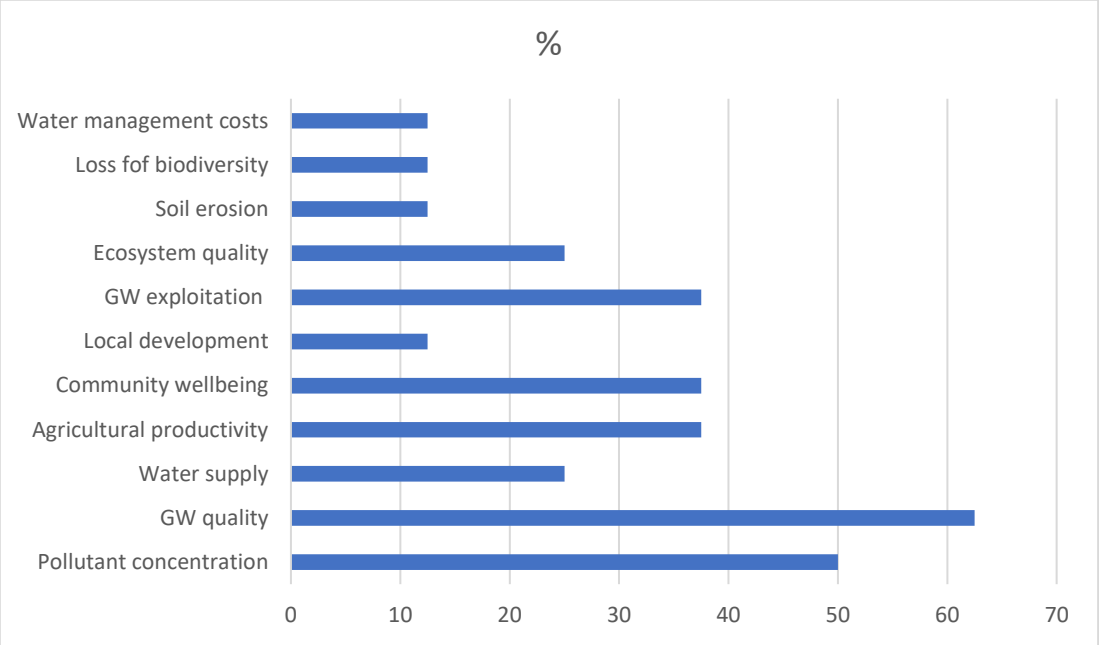

Figure 13(b). Percentage of stakeholders perceiving the impacts as important (medium and high importance degree).

For what concerns the main elements affecting the system vulnerability, stakeholders seem to agree on the "Infrastructural inadequacy" and "Limited innovation in the irrigation system". Whereas only few of them considered the lack of institutional cooperation as an important element affecting the system vulnerability. The impacts on the GW level and quantity represent the main issue to be addressed according to the involved stakeholders.

The FCM were also used to assess the degree of acceptability of the NBS. Similarly to the analysis carried out in the Ljubljana demo, two scenarios were developed and compared, i.e. the BAU and the NBS-implementation scenario.

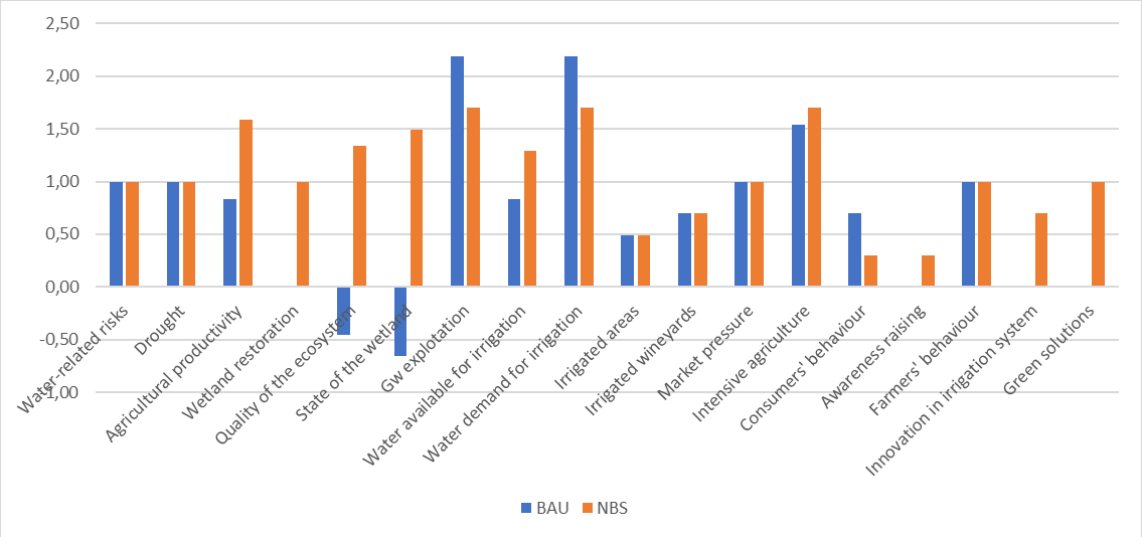

Figure 14. NBS impacts on the variables of the Medina city council FCM.

According to this stakeholder, the NBS implementation will allow to reduce the GW exploitation, and to increase the state of the wetland and the quality of the ecosystem. Nevertheless, the NBS implementation is expected to provoke an increase of the intensive agriculture due to the increase of the water available for irrigation.

Similar analysis were carried out for the other stakeholders in the demo, as described in the following table. The analysis of the FCMs and of the scenarios allowed us to identify the main barriers hampering the implementation of the NBS.

Table 15. Shows the results of the acceptability evaluation for the Ljubljana demo stakeholders.

Decision actor	Acceptability degree	Main barrier to NBS effectiveness
Avila government	Low	Lack of institutional cooperation
		Low impacts on pollution and community health
Regional Environ. Council	High	Lack of farmers' awareness
		Low level of innovation in the irrigation systems

Medina del Campo Municipality	Medium	Farmers' behaviour
		Low level of innovation in the irrigation systems
		Lack of farmers' awareness
Alhondiga (cultural association)	Low	Lack of territory control
		Expected increase of the intensive agriculture
		Low impacts on pollution and community health
ACUAES	Medium	Lack of funds
		Low level of innovation in the irrigation systems
Union de Campesinos	High	Low level of innovation in the irrigation systems
Salamanca university	Low	Lack of institutional cooperation for water management
		Low impacts on pollution and community health

The table shows that most of the stakeholders are keen to accept the NBS (medium to high). Those with a low degree of acceptance perceive the NBS effectiveness lower than expected, specifically in addressing central issues in their risk perception (i.e. pollution and community health).

4.3 The Lower Danube demo

The following stakeholders were interviewed in order to collect the individual risk perception:

INSTITUTION	ROLE
Municipality of Bistret - Environmental Department	They control the environment wellbeing, in particular the protected areas
Municipality of Calafat - European Projects Department	They implement improvement of policies, strategies, procedures and action plans of the local administration and monitoring of public services and utilities.
Municipality of Corabia City (vice Major)	The vice-mayor attributions are to support and to coordinate the following departments within the local municipality: the urbanism department, the market administration, the public servants personnel, the public service for water supply and waste water management, the sanitation department and the district heating department.
Municipality of Dabuleni - urbanism department	They operate to the development of the local infrastructure (roads, sewage and potable water)
Ministry of Agriculture and Rural Development (MARD)	They are the central public authority responsible to implement the government policies and strategies in the agriculture, food industry, rural development, fishing and aquaculture, land improvement, phytosanitary protection, sustainable soil management and connected research activities. Mard is also the management authority for implementation of the national rural development program and the eu policies in the agricultural sector. The ministry has also a major role in the implementation of the national strategy for adaptation to climate change.
Municipality of Turnu Măgurele (Local Development Dpt. Environment Protection Dpt., City Hall)	The local development department is monitoring the social and the business environment, evaluate and propose the actions and the activities to be implemented with the aim of local development; the environmental protection department is monitoring and evaluating the environmental conditions within the city and propose the actions and the activities that lead to better environmental conditions
WWF Romania	Environmental protection activities and its educational programs for environment and green economy.
Municipality of Zimnicea - International Projects department	They provide support for the implementation of the measures to reduce the flood risks and to protect the local community against floods. As local municipality they have also to implement the plan for emergency situations interventions and development strategy of the town, a guidance document for investment projects: infrastructure, education, economy tourism, social, etc.

The framework for the semi-structured interviews was applied in order to collect the information for the FCM development. Figure 15(a) and (b) show two examples of the developed FCM.

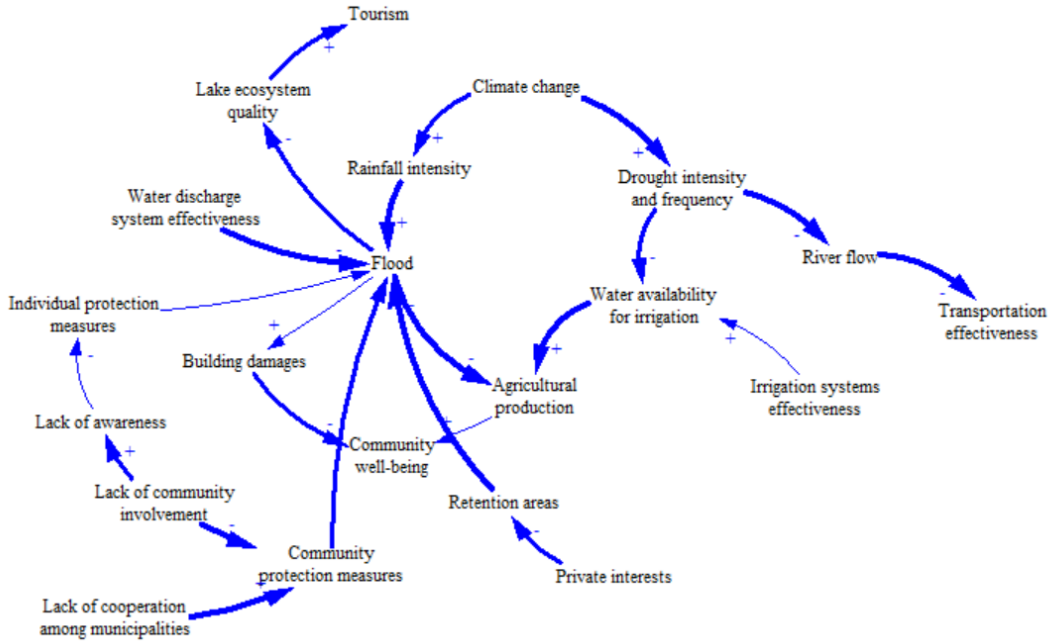

Figure 15(a). FCM representing the risk perception of the Bistret municipality.

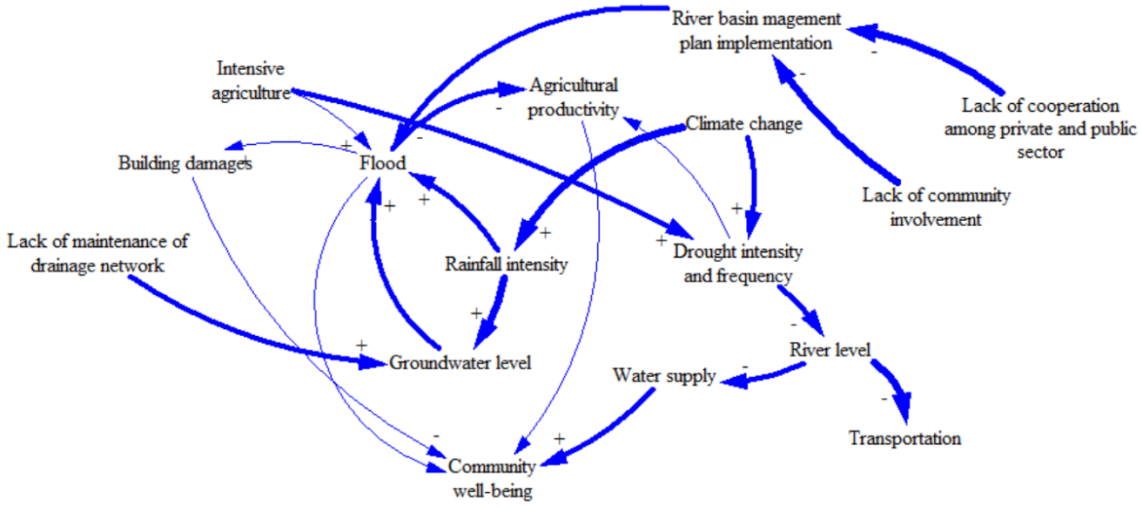

Figure 15(b). FCM representing the risk perception of the ZImnicea municipality.

The FCM have been analysed in order to identify the key elements in stakeholders' risk perception. To this aim, the centrality degree and the impact degree were calculated. Figure 16(a) and (b) show the flood impacts on the FCM variables of the Bistret and Zimnicea municipalities.

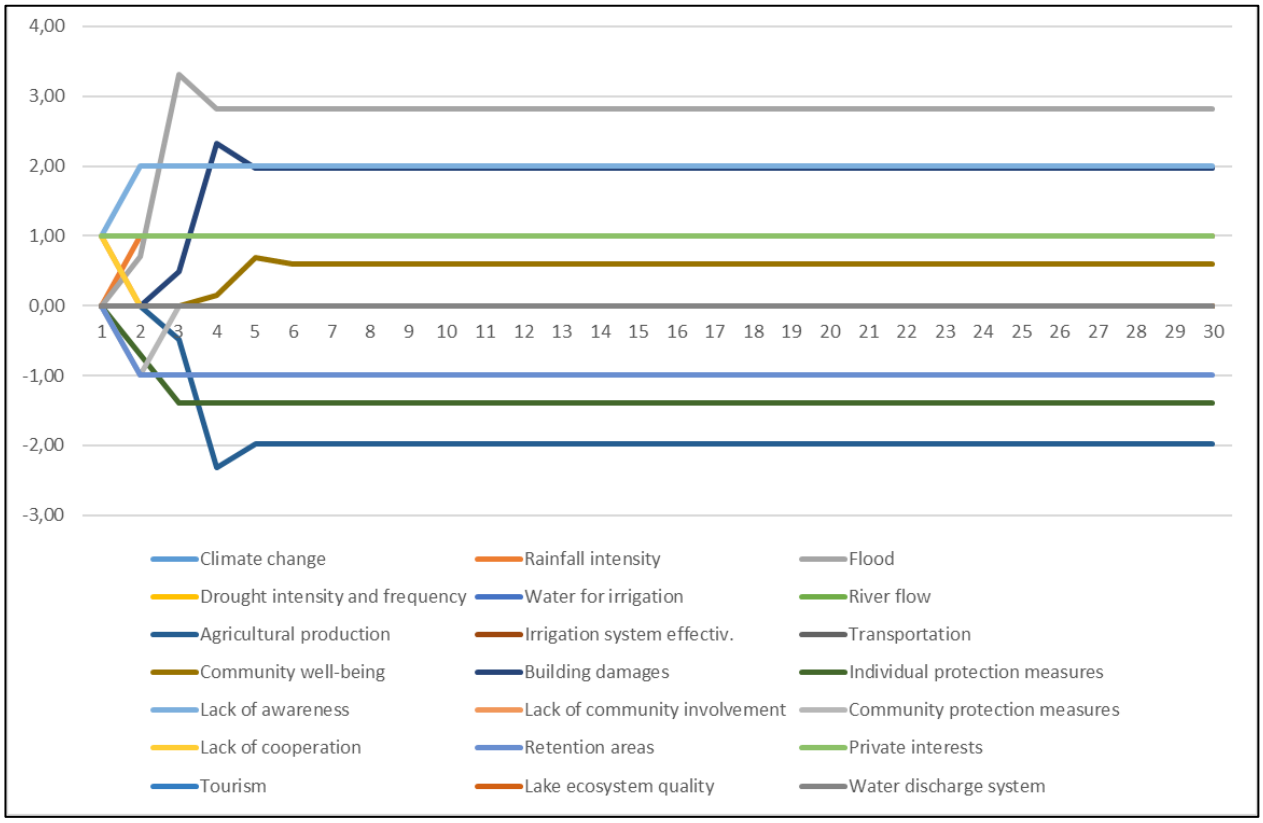

Figure 16(a). Expected flood impacts according to Bistret municipality FCM.

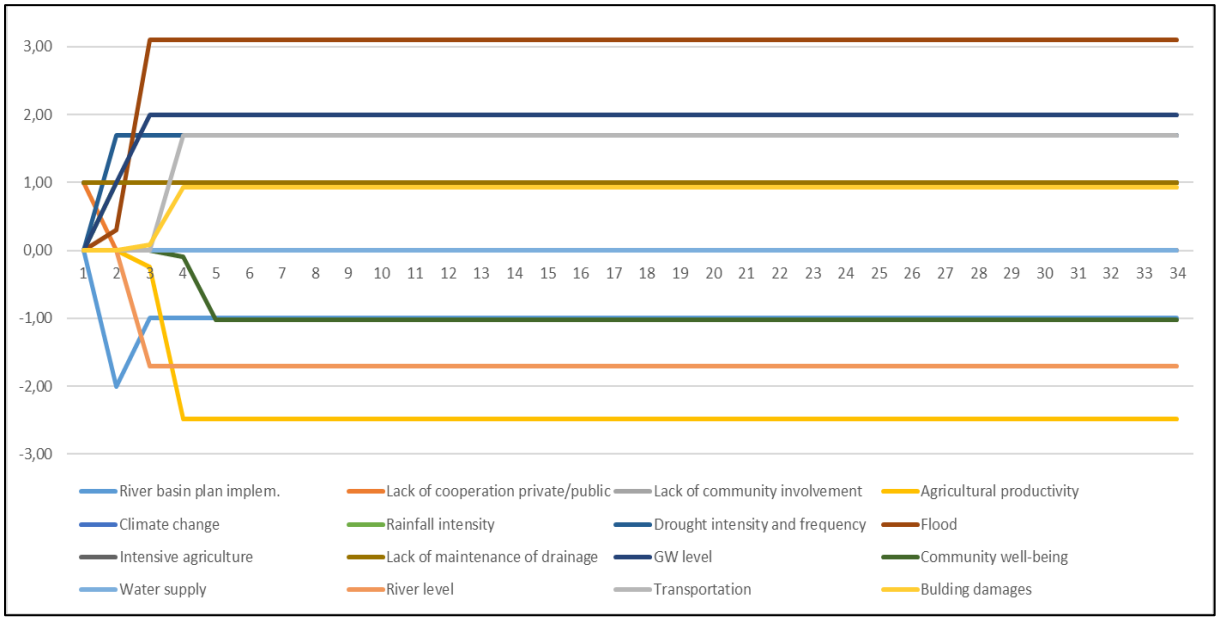

Figure 16(b). Expected flood impacts according to Zimnicea municipality FCM.

As already described in the previous sections, the aggregation of the centrality degree and impact degree allowed us to identify the most important elements in the stakeholders risk perception, as shown in the table 16.

Table 16. Main elements affecting the stakeholders' risk perception in the Lower Danube demo.

Decision actor	Type of variable	Variable	Centrality degree (index)	Impacts degree	Importance degree
Dabuleni Municipality	Vulnerability	Lack of embankment maintenance	Low	Weakly negative	Low
		Irrigation network effectiveness	Low	Negative	Medium
		Lack of institutional cooperation	High	Highly negative	High
		Building damages	High	Negative	High

	Primary impacts	Embakment erosion	Medium	Highly negative	High
		Agricultural productivity	Medium	Weakly negative	Medium
	Secondary impacts	Community security	Low	Weakly negative	Low
		River transportation	High	Highly negative	High
		Local development	Medium	Negative	High
Bistret Municipality	Vulnerability	Irrigation network effectiveness	Low	Weakly negative	Low
		Lack of institutional cooperation	High	Highly negative	High
		Lack of community involvement	High	Negative	High
	Primary impacts	Building damages	Medium	Weakly negative	Medium
		Agricultural productivity	Medium	Weakly negative	Medium
		River flow	High	Highly negative	High
	Secondary impacts	Community wellbeing	Medium	Weakly negative	Medium
		River transportation	High	Negative	High
Calafat Municipality	Vulnerability	Lack of urban planning implementation	Medium	Weakly negative	Medium
		Sewage system effectiveness	Low	Weakly negative	Low
	Primary impacts	River level	Medium	Negative	High
		Water supply	Low	Weakly negative	Low
	Secondary impacts	River transportation	High	Negative	High
		Community wellbeing	Medium	Weakly negative	Medium

Corabia Municipality	Vulnerability	Lack of urban planning implementation	High	Weakly negative	Medium
		Lack of awareness	Low	Weakly negative	Low
		Lack of institutional cooperation	High	Negative	High
	Primary impacts	Agricultural productivity	Medium	Weakly negative	Medium
		Embakment erosion	High	Highly negative	High
	Secondary impacts	River transportation	High	Negative	High
Rastul Vechi Municipality	Vulnerability	Lack of institutional cooperation	High	Negative	High
		Lack of community involvement	Medium	Weakly negative	Medium
		Flood plain urbanization	Low	Weakly negative	Low
	Primary impacts	Building damages	Medium	Negative	High
		Agricultural productivity	Medium	Negative	High
	Secondary impacts	Tourism development	Low	Weakly negative	Low
		River transportation	Medium	Negative	High
Turnu Margurele	Vulnerability	Infrastructure effectiveness	Low	Weakly negative	Low
		Lack of awareness	Medium	Weakly negative	Medium
		Lack of institutional cooperation	High	Negative	High
		Irrigation network effectiveness	Low	Weakly negative	Low
	Primary impacts	Agricultural productivity	Low	Weakly negative	Low
		Building damages	Low	Weakly negative	Low

		State of the environment	Medium	Weakly negative	Medium
	Secondary impacts	Local development	Low	Negative	Medium
		River transportation	Medium	Highly negative	High
		Community wellbeing	Medium	Negative	High
WWF Romania	Vulnerability	Deforestation	Medium	Negative	High
		Embakment maintenance	Low	Weakly negative	Low
		Lack of awareness	High	Negative	High
		Lack of community involvement	High	Negative	High
		Lack of institutional cooperation	Low	Weakly negative	Low
	Primary impacts	Embakment erosion	Low	Negative	Medium
		Agricultural productivity	Low	Weakly negative	Low
		State of the wetlands	Medium	Negative	High
	Secondary impacts	Loss of biodiversity	High	Highly negative	High
		Fishery production	Low	Negative	Medium
		Rural eco-tourism	Low	Negative	Medium
Ministry of agriculture and rural development	Vulnerability	Lack of institutional cooperation	High	Negative	High
		Lack of funding opportunities	Medium	Weakly negative	Medium
		Lack of awareness	Medium	Weakly negative	Medium
	Primary impacts	Agricultural productivity	High	Negative	High
		Community safety	Low	Weakly negative	Low
	Secondary impacts	State of the ecosystem	Low	Weakly negative	Low

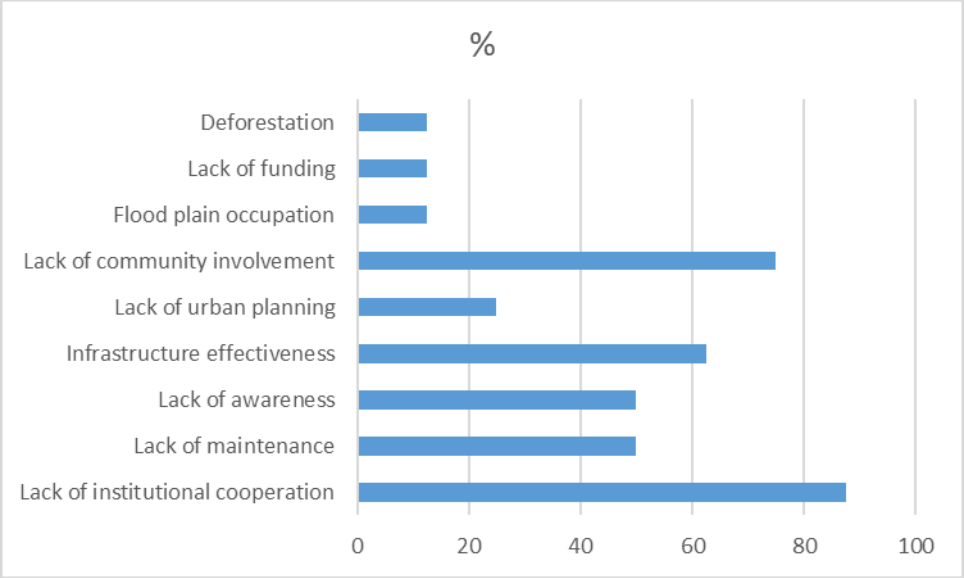

Figure 17(a). Percentage of stakeholders perceiving the elements of vulnerability as important (medium and high importance degree).

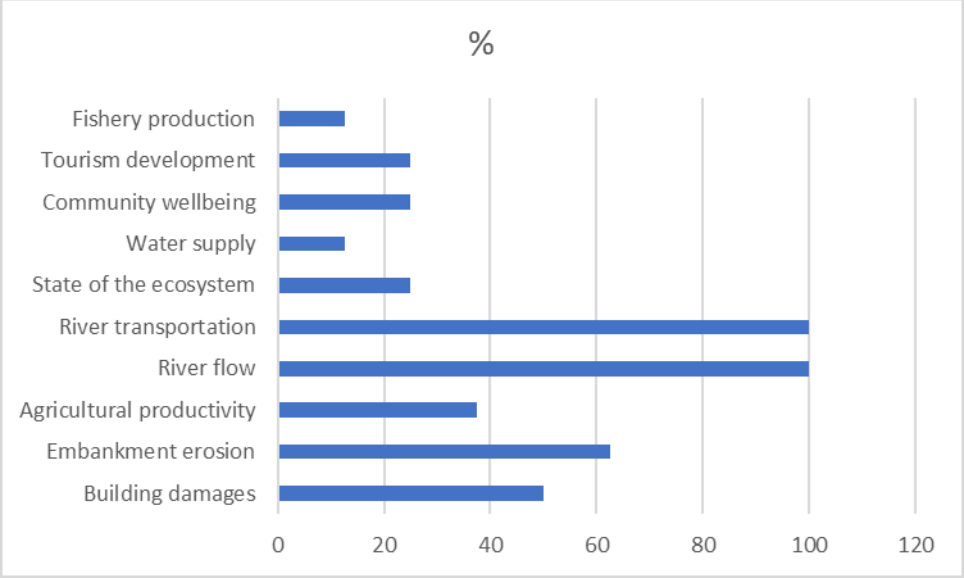

Figure 17(b). Percentage of stakeholders perceiving the flood impacts as important (medium and high importance degree).

As shown in figure 17(a) and (b), there is a high level of consensus about the role of lack of institutional cooperation in affecting the system vulnerability. The limited institutional capacity to involve local communities in the risk management activities is a result of the lack of cooperation, and strongly affect the system vulnerability. Finally, it is worth noting that most of the stakeholders perceived the limitation in river transportation as the most important impacts of the water-related risks.

The FCM were also used to assess the level of NBS acceptance, accounting for the stakeholders' risk perception. As already discussed, two scenarios were simulated and compared – i.e. the BAU and the NBS-based scenarios. Figure 18 shows the scenarios comparison for the Dabuleni municipality.

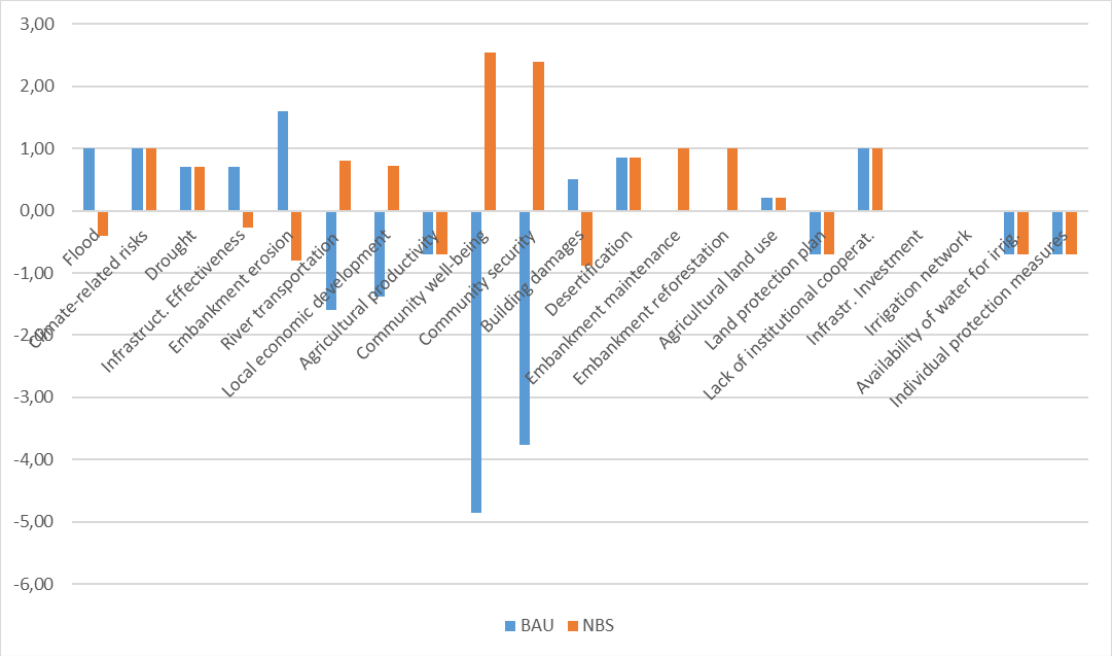

Figure 18. NBS impacts on Dabulemi municipality's risk perception.

Table 17. Shows the results of the acceptability evaluation for the Ljubljana demo stakeholders.

Decision actor	Acceptability degree	Main barrier to NBS effectiveness
Dabuleni Municipality	Medium	Lack of institutional cooperation
		Low level of implementation of land protection plan

Bistret Municipality	Low	Lack of institutional cooperation
		Lack of community risk awareness
Calafat Municipality	Low	Lack of institutional cooperation
		Lack of urban planning implementation
		Lack of community risk awareness
Corabia Municipality	Medium	Lack of institutional cooperation
		Lack of community risk awareness
Rastul Vechi Municipality	Medium	No expected impact on infrastructure effectiveness
		Lack of community awareness
		Lack of institutional cooperation
Turnu Margurele	High	Lack of institutional cooperation
WWF Romania	High	Lack of institutional cooperation
		Lack of funding opportunities
Ministry of agriculture and rural development	Medium	Lack of institutional cooperation
		Lack of funding opportunities
		Lack of community risk awareness

As shown in the table, there is a high consensus among the different stakeholders concerning the need to address the issues related to the very limited cooperation among the different institutions. The lack of community risk awareness represents another key barrier to be dealt with.

5. SOCIAL NETWORK ANALYSIS FOR NBS IMPLEMENTATION

This phase allowed to unravel the complexity of the network of interactions – both formal and informal – in order to identify the key elements in the network and the main vulnerability. The main scope was to define policy suggestions aiming at: i) enhancing the flow of information among the different institutional actors; and ii) to overcome the main barriers hampering the cooperation in risk management. The methodology described previously in the text was implemented in the two of the above mentioned NAIAD demos. Unfortunately, we are still collecting the information concerning the interaction network in the Lower Danube demo. Thus, we are not able to include these results in this deliverable. Nevertheless, the results from the

Ljubljana and the Medina demo allowed us to show the importance of the SNA in the NBS design and implementation process.

5.1 SNA in the Ljubljana demo

In order to analyse the way the different actors interact during a decision-making process for the implementation of risk management measures, the SNA methodology previously described was implemented. The framework for the stakeholders' interviews was meant to collect individual experiences concerning the interactions, both formal and informal, activated during risk management process.

Table 18. List of agents included in the SNA.

Actors	Acronym
Local community	LC
Expert - consultant	EX
Slovenian Water Agency	SWA
Slovenian Environmental Agency	SEA
Dept. of Environmental and Spatial Planning	DEP
Geological institute of Slovenia	GEO
Ministry of Agriculture	MIA
Dept. of Commercial Activities and Traffic	COM
Dept. of Environmental Protection	ENP
Civil initiatives	CIV
Public utility company for sewage management	WUT
European Commission	EC
Fishery Research Institute	FRI
Ministry of Infrastructures	MIF
Department for nature conservation	NAC
Department for civil protection and disaster relief	DRM
Information	**Acronym**
Flood early warning	I1
Urban plan rules	I2

Flood protection and reduction plan	I3
Rainfall monitoring	I4
Climate scenarios	I5
Statistical data	I6
River level monitoring	I7
Drainage infrastructures monitoring and assessment	I8
Damages monitoring and assessment	I9
Water management plan	I10
Land use data	I11
Water Framework Directive	I12
Flood Directive	I13

Table 19. List of tasks to be carried out.

Tasks	Acronym
Risk awareness raising	T1
Control of the territory	T2
Individual protection implementation	T3
Rescue activities	T4
Training and capacity building	T5
Designing community flood protection measures	T6
Infrastructure maintenance	T7
Providing economic resources	T8
Flood protection measures design	T9
Protecting the river habitat	T10
Early warning dissemination	T11
River maintenance and cleaning	T12

Using the results of the individual interviews, the following maps of interactions were developed.

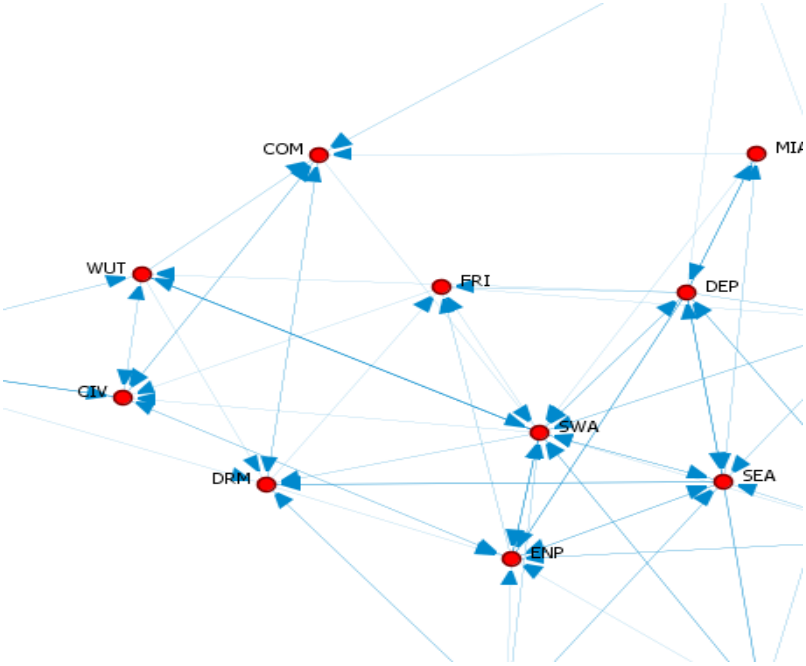

Figure 19. Agent x Agent map.

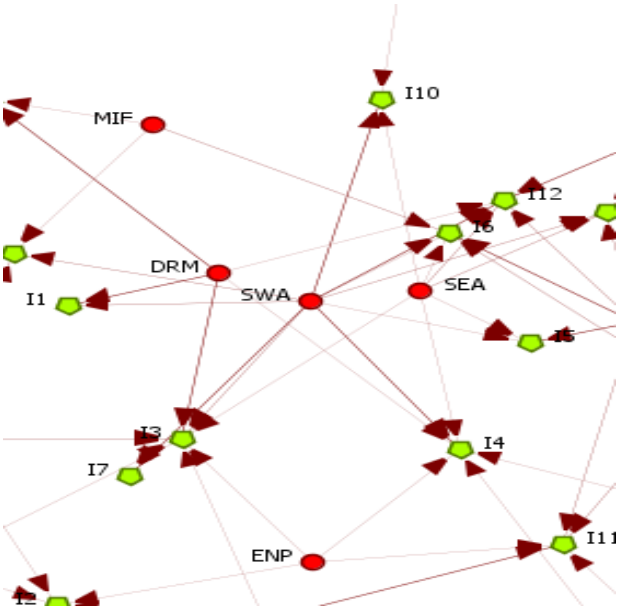

Figure 20. Agent x Information map.

The thickness of the links represents the importance assigned by the stakeholders to the interactions. Figure 19 and figure 20 show how the interviewed decision-makers perceive the interactions, both formal and informal, taking place during a decision-making process for the reduction of water-related risks. The developed maps were used to identify the key elements and the main vulnerabilities in the network.

Table 20. Most central elements in the network of interactions.

Entity	Measure	Nodes
Agent	Total degree of centrality	SWA – Slovenian Water Agency SEA – Slovenian Environmental Agency DEP – Dept. Of spatial planning
	Betweeness centrality	SWA – Slovenian Water Agency DRM – Dept. For civil protection CIV - Civil initiatives
	Most knowledge	SEA - Slovenian Environmental Agency ENP – Dept. of Environmental Protection SWA - Slovenian Water Agency EX – Experts/consultants
	Most Task	COS - Dept. of Commercial Activities and Traffic DRM – Dept. Of civil protection and disaster relief SWA - Slovenian Water Agency
Knowledge	Total centrality degree	I5 – Climate scenarios I3 – Flood protection and reduction plan I9 – Damage monitoring and assessment
	Closeness centrality	I2 – Urban plan rules
	Most task	I3 – Flood protection and reduction plan I1 – Early warning I2 – Urban plan rules I10 – Water management plan
Task	Total centrality degree	T2 – Control of the territory

		T6 – Designing protection measures T7 – Infrastructure maintenance

As expected, the SWA plays a key role in the process, since it has strong connections with most of the other institutional actors. It is also interesting to notice that the CIV actor has a pretty high value of the betweennes centrality. This means that, due to its dense network of short (fast) connections, this actor could rapidly share information with the others. Specifically, CIV could move rapidly information from the institutional system toward the local community. Concerning the pieces of information, the most important ones are those related urban planning and flood protection measures.

The results of the analysis allow also us to draw some preliminary conclusions concerning the main weakness in the network of interactions, that is, the elements that can represent a barrier to the effectiveness of the collective process for NBS design and implementation. Considering the measures described in table 7, the following elements of vulnerability were identified. Among the actors, CIV represents a vulnerability since it has a pretty high betweennes centrality but rather low most knowledge degree. This means that, due to the limited access to important information this actor cannot play its' role in the network. Similarly, the COS is quite important in the network due to the high number of tasks to be carried out. Nevertheless, this actor is characterized by only few links (low centrality degree).

The way the knowledge is managed in the network could represent a key issue to be addressed. Specifically, the urban plan rules and the flood protection rules (both for individual and collective measures) play a key role but they are not sufficiently shared among the different actors. It is worth noticing that these results are coherent with the FCM analysis. As described in table 12, one of the most important barriers to the NBS implementation was the low level of urban planning rules. The SNA results demonstrated that this is mainly due to the incapability of many decision-actors to have access to this key information.

Moreover, the early warning is important because it can activate several tasks, but it is not easily accessible by the actors in the network. CIV and the local community (LC) need to have access to this information, in order to reduce the flood damages.

5.2 SNA in the Medina demo

A group mapping workshop was organized in this demo to collect all the required information for performing the SNA. In order to facilitate the group discussion, three pre-defined lists were used in the workshop: i) the list of actors involved in the risk management process; ii) the list of the tasks performed by the different actors in the risk management process; iii) the list of

information used in the different tasks of the risk management process. The lists were defined referring to the institutional analysis carried out by WP3, as shown in the following.

Table 21. List of actors.

Actors	Acronym
Duero River Basin Authority	CHD
MAPAMA	MP
Civil Protection Agency	CPA
Municipality	MU
Provice Authority	PA
Mancomunidades	MC
University	UNI
Regional Authority – Economy	RAE
Regional Authority – Agriculture	RAA
Regional Authority – M.A i fomento	RAM
ONG	ONG
Local Association	LA
Water User Association	WUA
Farmers	FAR
Farmers Association	FAA
Private and Public enterprises	PPE
Insurance companies	IC

Table 22. List of information.

Information	Acronym
Flooding National Plans	I1
Planification Urban	I2
Meteorological Information	I3
River and Aquifer state	I4
Agricultural Subsidies	I5
Water cost	I6

Piezometric level	I7
Irrigated Crops Areas	I8
Ecosystem state	I9
Geomorphological aspects	I10
Emergency Responses Resources	I11
Water use control	I12
Hydrologic plan	I13
Water demand	I14
GW quality	I15
Exposed population	I16
Caudal de ríos/River flows	I17
Investigation on climate risks	I18
Available economic resources	I19
Drought management plan	I20
Crop types	I21
Water basin regulations and directives	I22

Table 23. List of tasks.

Tasks	Acronym
Public water regulation	T1
Water rights management	T2
Flood risk management plan development	T3
Drought risk management plan development	T4
Spatial panning in natural areas	T5
Regional strategies for sustainable development	T6
Monitoring environmental quality	T7

Agricultural development	T8
City planning	T9
Water distribution at urban level	T10
Flood risk management at local level	T11
Technical support to water distribution	T12
Financial support to water distribution	T13
Technical support to environmental resources management	T14
Financial support to environmental resources management	T15
Regulation of water distribution for irrigation	T16
Water price definition	T17
Farmers' subsidies definition	T18
Protecting local cultural and environ. Heritage.	T19
Community awareness raising	T20
Environmental protection control	T21
Producing research on water-related risks	T22
Legal framework definition for environmental and civil protection	T23
Insuring risks	T24
Dams management	T25
Surface water distribution	T26

The first phase concerned the Actors X Actors interactions. Therefore, participants were required to draw the connections taking place among the different actors. The basic question in this phase was: "with whom do you interact while addressing the water-related risks issues?" They were also required to weight the connections according to their perceived importance. In order to facilitate the discussion, the participants were clustered in five heterogeneous groups.

Inputs from the groups were collected and, finally, aggregated in order to carry out the quantitative social network analysis.

The following figures show the results obtained from the different groups.

Figure 21. Maps showing the stakeholders' understanding about the Agent x Agent interactions.

The inputs obtained from each group were, hence, aggregated and mapped. The following figure shows the Social Map.

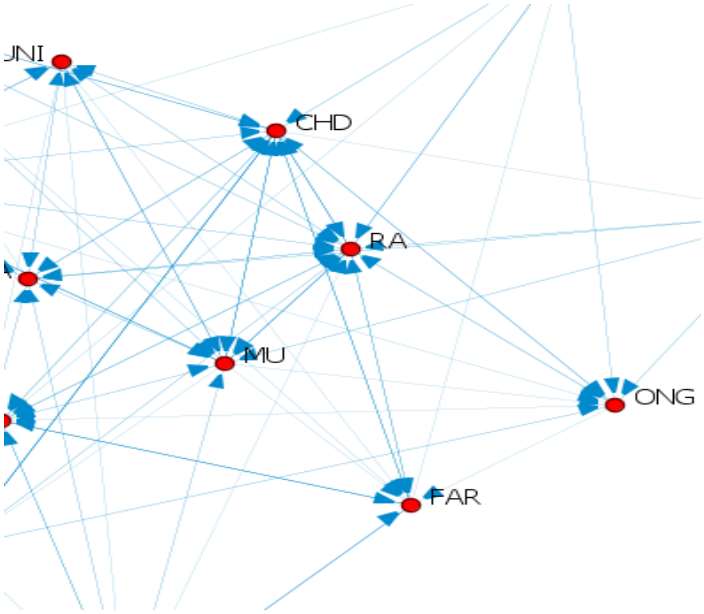

Figure 22. Social Network Map.

Similarly, the other meta-networks were developed.

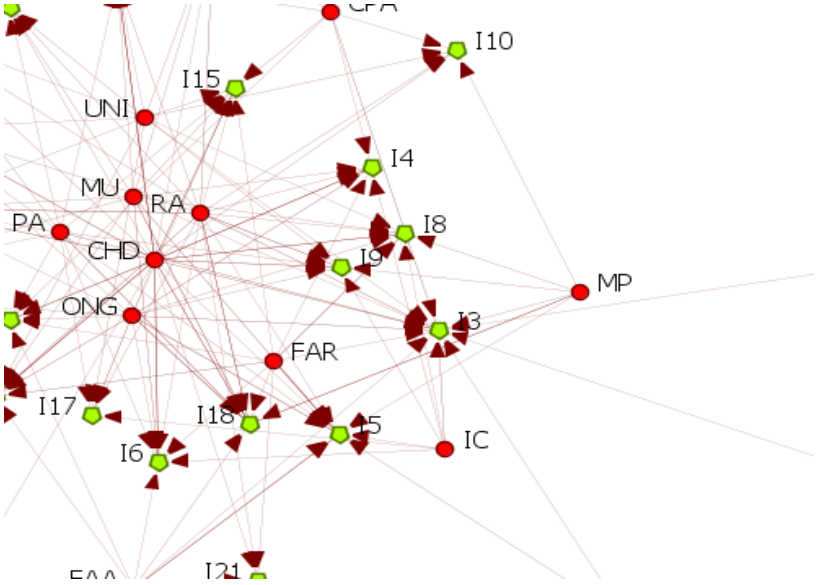

Figure 23. Actors X Information network.

This map shows the connections between each actor and the different pieces of information. In the adopted approach, a connection means that an actor could use and/or produce such information.

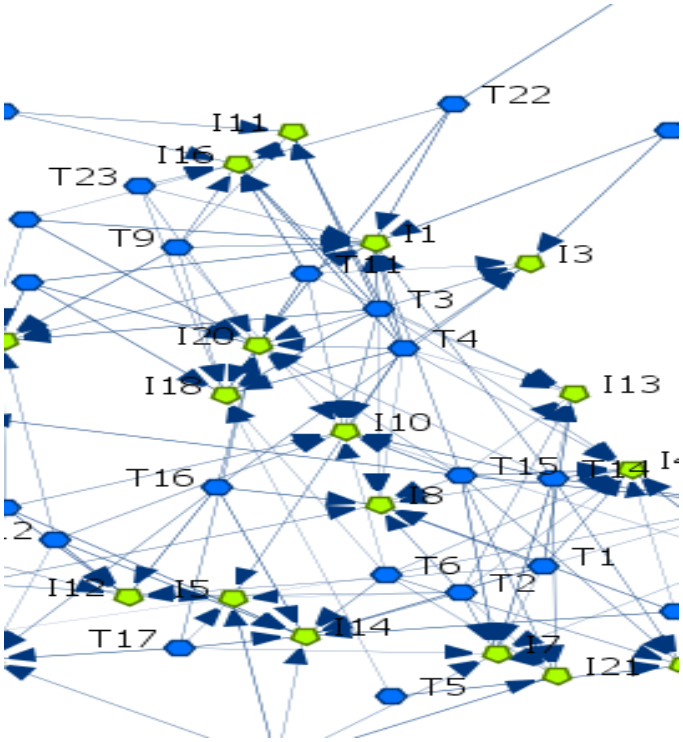

Figure 24. Task information connections.

The task-information map shows the pieces of information used by the different actors in order to fulfil the required tasks. The aggregation of the different meta-matrixes allowed us to develop the Organizational Map, as shown in the following figure.

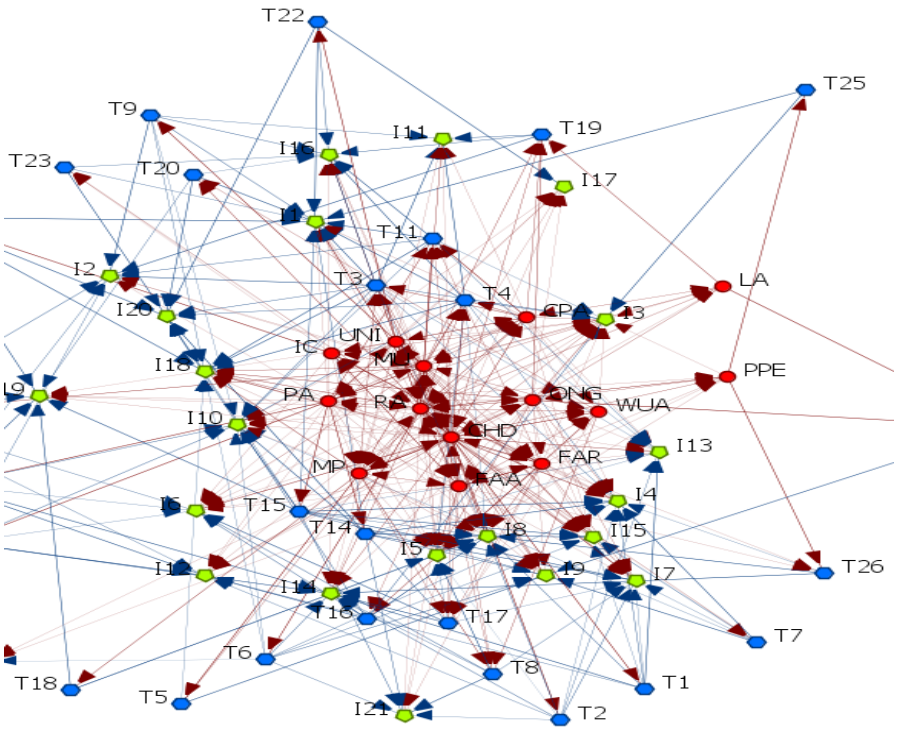

Figure 25. Organizational Map showing the connections among Agents-Information-Tasks.

Figure 25 shows the actual complexity of the interaction mechanisms supporting the risk management decision process. Failure in this network – i.e. lack of an information, missing cooperation for task implementation, etc. – could provoke uncontrollable cascading effects leading to failure of the risk management process conceived as a collective process. Therefore, it becomes crucial for the decision makers to enhance their comprehension of this complexity, in order to implement actions aiming at fostering the actual collaboration in risk management.

Graph Theory measures were implemented in this work in order to identify the key elements in the network and the key vulnerability. The following results were obtained.

Table 24. Key elements in the Medina network of interactions.

Measures	Key actor	Meaning
Total centrality degree	CHD Regional authority	These actors are characterized by a high number of connection (both in- and out-) with most of the other agents in the network.

	Municipalities	
Betweennes Centrality	Civil Protection Agency Municipalities Water Users Associations	These actors occur on many of the shortest paths between other agents. This means that these actors can easily move information from one part of the other of the network.
Most knowledge	CHD Regional Authority Province Authority	These actors have access to important pieces of information.
Most task	CHD MAPAMA Regional Authority	These actors are called to perform the most important tasks.
Most task (knowledge network)	Flood management plan Investigation on risks River and Aquifer state Water demand Drought management plan	These pieces of knowledge are needed to performed the most important tasks

The developed network was also analysed in order to identify key vulnerabilities, as shown in the flowing table.

Table 25. Key vulnerabilities in the Medina network of interactions.

Type of elements	Key vulnerability	Meaning
Agent	Water Users Association	This actor has a high degree of betweennes centrality but low degree of most knowledge. Therefore, it has access to limited knowledge impeding its role as information providers. They represents a barrier to information sharing rather than a bridge.
	MAPAMA	This actor has a high degree of most task and a low degree of centrality degree. This is mainly due to the limited number of heavy links connecting this actor to the others in the network.
	Insurance companies	This actor has a pretty high knowledge specialization, that is, it has almost exclusive access to an important piece of knowledge – i.e. investigation on risk – but has a very low degree of connection with

		the other actors. This could negatively affect the information sharing process.
	Farmers association	This actor is characterized by a pretty low centrality degree. The lack of important connections – e.g. with the municipalities – could affect its capability to facilitate the information sharing.
Knowledge	Investigation on risks	This information should play a crucial role since it has a high most task degree (it supports a large number of tasks). Nevertheless, it is poorly shared among the different agents (low degree of most knowledge).
Task	Water right management	This task could facilitate the implementation of numerous other tasks. Nevertheless, only the CHD is responsible for the correct implementation of this task.

The SNA results allows us to detect the main causes of the barriers to the NBS implementation mentioned by the different stakeholders. As described in table 15, several barriers were related to farmers' behaviour and the difficulty in introducing innovation in the farming activities. The SNA showed that this is mainly due to the lack of connections of farmers association, and due to the incapability of the water users association to have access to key information.

These results could be used to co-design improvements of the interaction networks in the Medina del Campo demo, aiming at fostering an actually collaborative risk management decision-making process, and, in doing so, to facilitate the implementation of NBS in the demo.

DISCUSSION

We would like to focus this section on two different, but equally import, issues. On the one hand, we assess the suitability of the proposed methodology for eliciting and structuring individual risk perception, and for analysing the interaction mechanisms among the different institutional actors in risk management processes. This will facilitate the replicability of the adopted methodology. On the other hand, the results of the analysis are used to draw some preliminary conclusions concerning the potential barriers hampering the design and implementation of NBS. Policy suggestions aiming at overcoming these barriers are derived from this discussion.

Concerning the first issue, the experiences carried out in the three demos show the FCM capability to structure the complex cause-effect chains affecting the stakeholder's risk perception. To this aim, the framework for the semi-structured interviews was organized according to the *mean-end* approach. That is, interviewed were required to describe the "risk-primary impacts-secondary impacts-vulnerability-measures" perceived chain of causality. This facilitates the developing of the individual FCM starting from the stakeholders' narratives.

Moreover, the adopted hierarchical structure of the FCM facilitates the identification of the most important elements in the stakeholders' risk perception, through the aggregation of the centrality degree and the impacts degree, as describe above in the text. A validation phase was carried out with selected stakeholders in order to assess the reliability of the centrality and impact degrees. In most of the cases, the central issues mentioned by the stakeholders coincided with those identified through the adopted approach.

Besides, the work carried out in the three demos demonstrated the suitability of the FCM to assess the acceptability degree of the NBS. To this aim, the FCM were used to simulate qualitative scenarios activating and de-activating the variables associated to the NBS in the stakeholders' FCM. The comparison between scenarios and the analysis of the cause-effects chains in the FCM allowed us to detect the main elements influencing the degree of acceptance. These results could be used to improve the communication among the different stakeholders in order to enhance the acceptance.

The organizational SNA was implemented in this work to unravel the complexity of the network of interactions taking place during risk management processes. Both formal and informal interactions were accounted for in this work. Compared to other SNA approaches, the Organizational Risk Analysis method (ORA), implemented in this work, and does not limit the analysis to interactions among the decision actors. Investigating how information and tasks affect the interaction mechanisms is another important results of the adopted methodology. AS shown in the Ljubljana and Medina del Campo demos, the SNA results allowed us to detect the causes of the main barriers to the design and implementation of NBS according to the stakeholders' understanding. In many cases, these barriers were provoked by failures in the interaction networks involving actors-information-tasks, e.g. the low level of implementation of the urban plan in the Ljubljana demo was caused by the low level of sharing of the information related to the urban plan rules.

Although we are aware that the results described in this work are demo-specific, general conclusions can be drawn concerning the interaction between risk perception and NBS implementation. It is worth mentioning that in two demos the majority of the involved stakeholders cited institutional-related issues as the main elements affecting the vulnerability of the system toward water-related risks. According to their understanding, the lack of institutional coordination and/or capability to control the territory hampered the actual implementation of risk management strategies and urban plans for climate adaptation. This is particularly true in the Lower Danube demo. Only few of them mentioned physical elements of vulnerability, e.g. infrastructure effectiveness. It is also interesting to notice that in the Ljubljana demo, the stakeholders' opinions converged around only few important elements of vulnerability. In the Medina del Campo demo, besides the lack of innovation in infrastructure design and management (mainly irrigation system), that was considered important by many

stakeholders, there was a wide range of variables mentioned during the interviews. This represents an issue that needs to be accounted for during the convergent thinking phase, as described further in the text.

The institutional-related issue represents also the most important barrier hampering the effectiveness of the NBS according to the stakeholders' perception. The lack of risk awareness and the low level of institutional cooperation were perceived as issues that need to be addressed prior to start the implementation of the NBS. Therefore, integrated "soft" – i.e. policies for raising risk awareness, training and capacity building, institutional cooperation protocols, etc. – and green solutions need to be discussed with stakeholders and decision-makers. This result will influence the next phases of the NAIAD implementation in the different demos.

The FCM analysis carried out in the three demos will be used in the next phases of NAIAD implementation as basis for the convergent thinking phase. In this first phase, the activities carried out aimed at highlighting the main differences among the stakeholders' problem understandings, and to analyse the main reasons behind these differences. The convergent thinking phase will aim at facilitating the consensus achievement among the involved stakeholders for what concerns the most suitable risk management measures, the criteria to be used for the selection and the those needed for the assessment of the measure effectiveness. To this aim, the individual FCM will be aggregated, accounting for the main differences, as suggested by Ozesmi and Ozesmi (2004). The obtained Social FCM will represent the system exposed to the water-related risks as perceived by the stakeholders. The Social FCM will be used to facilitate the discussion among the involved stakeholders about the most suitable risk management measures, and specifically the NBS, and their expected impacts on the system. The results of the centrality and the impact degrees will be used to identify the most important goals to be achieved in order to reduce the water-related risks. Starting from the tables described above in the text, the involved stakeholders will be required to reach a satisfactory consensus over the most important ones. This restricted set of elements will represent the set of criteria for the selection of the most suitable risk management measures.

The organizational SNA highlighted two important elements that need to be accounted for in order to enhance the effectiveness of the decision-making process for NBS design and implementation. Firstly, the involvement of local communities needs to be strengthened. The analysis carried out in the different demos emphasizes the potentialities of local communities to move rapidly risk information within the interaction network. This is mainly due to fast (short) connections with the other members of the community. Nevertheless, the links between the community and the institutional actors seem to be weak in many cases. Moreover, local community (or representatives of the community) does not have access to key information, and/or is not capable to fully comprehend it. Therefore, efforts need to be carried out in order to enhance the community's involvement in the risk management process.

The SNA in the NAIAD demos showed also the key role played by "operational" information that is the plans and the procedures regarding the management of the territory and the management of the water-related risks. This information is key in the networks because it enable other information to be retrieved and used, and it facilitates the implementation of several tasks. Nevertheless, this information often has low level of access and it is poorly shared among the different decision-makers. Efforts need to be carried out in order to facilitate the sharing of this information in the institutional network. This will positively affect the capability of the different decision-makers to cooperate in designing and implementing risk management measures.

CONCLUDING REMARKS

This work describes a methodology based on the implementation of Fuzzy Cognitive Map and Social Network Analysis aiming at eliciting, structuring and analysing the stakeholders' perception of risk. Specifically, FCM have been implemented to structure the cause-effect chain – i.e. from the climatic drivers, to the main risks, and, finally, to the primary and secondary impacts – affecting the stakeholders' risk perception. To this aim, a framework for individual semi-structured interview was developed and implemented in three of the NAIAD demos.

The analysis of the FCM results allowed us to detect and analyse similarities and differences in risk perception. The results described in this document show how the same problem can be perceived differently by different actors. That is, they focus their attention on some elements of the system instead of some others. They attribute different priority to the issues that need to be addressed. They have different goals to be achieved, and actions to achieve those goals. Being aware of these difference, of the ambiguity in problem understanding and framing, is a *sine-qua-non* condition to transform ambiguity from a barrier to the collective decision-making process, to an enabling factor of the creativity in the collective decision-making process.

The SNA allowed us to detect the main vulnerabilities in the network of interactions among the different institutional actors. The assumption here is that risk management processes are basically collective decision-making processes. Therefore, barriers hampering the cooperation and the flow of information need to be detected and addressed.

The results described in this document will support the next phases of the stakeholders' involvement in the demo. Specifically, the ambiguity analysis will be used to support the convergent thinking phase, whose main scope is to facilitate the debate among the different stakeholders to achieve a satisfactory level of consensus over: i) the main goals to be achieved through the implementation of the risk management action; ii) the measures that need to be implemented; iii) the criteria for the evaluation of the measures' effectiveness.

The convergent thinking phase is the focus of the Task 3.3.

The results of the WP3 activities in these three demos will be used to develop guidance for ambiguity analysis to be implemented in the other NAIAD demos. Specifically, this document will allow the demo leaders to carry out the semi-structured interviews, to develop and analyse the individual FCM. The methodology transfer process already started involving the Rotterdam and the Thames demo.

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