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EXECUTIVE SUMMARY

This deliverable is meant to describe the lessons learned in NAIAD concerning the role of risk perception and stakeholders' engagement in NBS co-design and implementation. Specifically, the efforts done for affecting stakeholders' perceptions of NBS effectiveness and, thus, for enhancing their social acceptance are described in this deliverable. The report is structured around three main topics arose during NAIAD implementation, that is: i) the complexity of the cause-effects chains affecting NBS effectiveness and the role of socio-institutional measures; ii) the need to account for the existence of potential trade-offs among different stakeholders in benefiting from NBS implementation and co-benefits production; iii) the role of communication and information exchange in facilitating NBS co-design and implementation.

Concerning the first issue, the NAIAD activities carried out in several demos demonstrated that the implementation and the effectiveness of NBS in reducing water-related risks and producing co-benefits is influenced by socio-institutional barriers – e.g. lack of community's engagement, lack of community risk awareness, etc. – that need to be overcome. As discussed further in this deliverable, the participatory modelling approaches adopted in NAIAD allowed to detect these barriers, to analyse their impacts on NBS effectiveness, and to define socio-institutional measures capable to transform the barriers into enabling factors. Besides, the engagement of stakeholders in developing the model enabled a collective learning process enhancing participants' understanding about the need to adopt an integrated approach in NBS design and implementation.

NBS success is mainly because of their capability to produce a wide range of co-benefits. However, diverse beneficiaries might have diverse perception of and preferences over the co-benefits. The production of one co-benefit might hamper the production of others – e.g. the creation of wetland could reduce the agricultural productivity – causing potential conflicts between stakeholders with different preferences. The work done in NAIAD demonstrated the importance of detecting potential trade-off among different co-benefits in the early phases of the NBS design. This is in line with previous works that showed how conflicts among stakeholders might hamper the effective implementation of environmental policies, i.e. NBS implementation.

Finally, the activities carried out in different NAIAD demos showed that the NBS design implementation is a complex activity, whose effectiveness does not depend exclusively on the capacity and resources of the involved decision-makers, but also on the number and quality of the relationships with each other. Among the different barriers that need to be detected and overcome to enable the NBS implementation, this work focuses on the collaboration barriers,



that is, those barriers caused by lack of effective collaboration among different decision-makers and stakeholders involved in NBS implementation.

Efforts have been carried out to enhance the transferability of the methods and tools used in NAIAD demos in other contexts. Therefore, contrarily to the other WP3 deliverables, grounded in the demos' activities, this document refers to NAIAD demo simply as example of the potentialities of the implemented methods and tools.

We are aware that many issues remain unaddressed at the end of NAIAD. Therefore, a section in the discussion is dedicated to describing the needs for further researches in NBS co-design and implementation. Specifically, the usability of semi-quantitative models for supporting economic investments is a key issue that need to be addressed. Moreover, improvement are needed for the tools and methods adopted in NAIAD to make them suitable to analyze the synergies among the different actions operating at different scales for reducing the water-related risks.



1. INTRODUCTION

The main goal of WP3 activities within the NAIAD framework, and in the different Demos in which it was directly involved – and/or it supported the local partners – was to facilitate the design and implementation of NBS as measure for reducing water-related risks, through the active stakeholders' involvement. Specifically, WP3 aimed at enabling the integration between risk perception and risk assessment as a way for developing effective measures for coping with risks. To pursue this goal, WP3 activities focused mainly on: i) eliciting and structuring stakeholders' risk perceptions, accounting for the main differences and similarities (ambiguity analysis); ii) integrating stakeholders' knowledge and risk perception in the modelling and analysing of water-related risks and NBS effectiveness; iii) detecting and analysing the key barriers hampering the effective implementation of the NBS; iv) provide policy suggestions for enhancing NBS social acceptance and, thus, facilitate their effective implementation.

Nature-based solutions (NBS) have become a valid alternative to grey infrastructures – i.e. hard, human-engineered structures (Palmer et al., 2015) – for coping with climate-related risks in urban and rural areas alike (Raymond et al., 2017; Calliari et al., 2019; Frantzeskaki, 2019). NBS are increasingly recognized for their capacity to address specific societal challenges – e.g. reducing water-related risks – foster the functioning of ecosystems and to generate additional environmental, economic and social benefits that are considered as essential backbones of actions for climate-change mitigation and adaptation (Bain et al., 2016; Kabisch et al., 2016; Josephs & Humphries, 2018). Nevertheless, the transition of the risk management system from the grey solutions toward NBS is still slow (Wihlborg et al., 2019). Among the different issues that need to be addressed in order to enable the implementation of NBS as measures for reducing climate-related risks, the social acceptance and the low level of stakeholders' engagement in solutions co-designing and implementation play a key role (Pagano et al., 2019; Santoro et al., 2018; O'Donnell et al., 2017).

NBS and the associated benefits and co-benefits have many potential uses with different values attached, that can be perceived differently from different beneficiaries. The differences among the stakeholders concern the kinds of benefits to be valued, and the values to be attached, which are strongly affected by the individuals' benefits perception (Sanon et al., 2012; Jacobs et al., 2016; Small et al., 2017). Neglecting these differences and ignoring the consequences of trade-offs between values held by different stakeholders, which in many cases are not well represented in the decision-making process, may lead to conflict, hampering the effective implementation of NBS. Moreover, stakeholders' engagement in participatory processes may be turned into an often controversial and futile process (Brugnach & Ingram, 2012; Giordano et al., 2017; Howe et al., 2014; Jacobs et al., 2016; Small et al., 2017; Wam et al., 2016; Shrestha



& Dhakal, 2019). Therefore, NBS design and implementation should be based on inclusive and equitable participatory processes, capable to ensure the active involvement of all different categories of stakeholders, and to reflect the diversity of meanings and interpretations that the inclusion of multiple actors brings (Brugnach & Ingram, 2012; Cohen-Shacham et al., 2019). Therefore, disciplined methods to reflect on the sources of ambiguity, indeterminacy and complexity, and facilitating the dialogue, aligning divergences and reducing conflicts among different decision-makers are needed (Jasanoff, 2007; Santoro et al., 2018).

Most of the approaches in the scientific literature aiming to eliminate the conflict among different decision-actors neglect the relationships among decision-actors and the role of social network in influencing decision-actors' behaviour. They are seen as independent individuals (Liu et al., 2019). Nevertheless, individuals do not make decisions in a vacuum, but social interactions can alter choices and decisions (Kolleck, 2013; Siegel, 2009; Sueur et al., 2012). Evidences demonstrate that the structure of the social networks, both in terms of patterns of connections and the way individuals are distributed across them, affect interdependent behaviour of the agents and the aggregated outcomes of the collective decision process (Siegel, 2009). Moreover, the degree of influence depends on the strength of the relationships between two decision-makers (Liu et al., 2019). Though interaction mechanisms, different decision-actors tend to align their problem frames, overcoming the barriers due to the presence of ambiguity (Brugnach et al., 2011; Dewulf & Bouwen, 2012).

There is a wide support in decision and conflict analysis for distinguishing two categories of conflict, i.e. i) those provoked by existing differences among decision-makers over problem perceptions and preferences; ii) conflicts due to disharmonious relationships among decision-actors. Correlations have been detected between these two kinds of conflict in multi-actors decision-making environment. That is, conflicts may not occur between decision-makers with a rather different problem frames, but with good relationships. Conversely, highly similar opinions cannot ensure the absence of conflicts between decision-makers if they distrust each other (Liu et al., 2019). It has been suggested that divergent frames can still yield organized collective action when the interaction frames are sufficiently aligned (Giordano et al., 2017).

Starting from these premises, WP3 activities aimed at demonstrating that effective stakeholders' engagement processes, based on the elicitation and integration of the different risk and problem perceptions, and on the analysis of the main sources of ambiguity, is key in enhancing NBS social acceptance.

This deliverable aims at: i) summarizing the main findings; ii) critically analyse the effectiveness of the activities carried out in the demos, in order to enhance the replicability of the methods



and tools developed/adopted; iii) provide policy suggestions for enhancing NBS social acceptance and, thus, facilitate their effective implementation.

Next section is focused in the development of integrated models for supporting the NBS co-design. Section 3 describes the role of risk perceptions for co-benefits identification and valuation. Section 4 describes the role of social network in facilitating the NBS co-design and implementation. Section 5 is focused on the integration of local and scientific knowledge for developing innovative and integrated monitoring system for assessing NBS effectiveness. All sections are structured around three main topics, i.e. what has been done in NAIAD, what has been learned, how to replicate. Concluding remarks are drawn at the end of the document.

The sections forming this deliverable describe the main lessons learned during the WP3 activities implementation in the different NAIAD demos. Specifically, the experiences carried out in three NAIAD demos are described in this deliverable. Namely: i) the Ljubljana and the Lower Danube demo for what concerns the integrated and participatory modelling for NBS design; ii) the Lower Danube for the co-benefits assessment and trade-off analysis; iii) the Medina del Campo demo for the networking interventions for NBS design and implementation.

2. THE DEVELOPMENT OF INTEGRATED MODELS FOR NBS CO-DESIGN: THE ROLE OF RISK PERCEPTIONS

This section is dedicated to describe the role of integrated models in supporting NBS co-design and evaluation. The activities described in this section were carried out in cooperation with WP5. Two kinds of integrated models were implemented in NAIAD demos, i.e. System Dynamic Model (SDM) and Fuzzy Cognitive Map (FCM). These approaches are extensively described in NAIAD deliverable D5.5. These modelling approaches were selected for three main characteristics, that made them suitable for addressing the complex issues related to NBS co-design and assessment. Firstly, both SDM and FCM are based on system thinking approach – i.e. the evolution of the modelled system is affected by the structure of the interconnections among the different elements. Therefore, these two modelling approaches were considered suitable for mapping and analyzing the complex web of interactions involving physical, ecological and socio-economic factors affecting the NBS effectiveness. Secondly, these methods were selected due to their capabilities to simulate the dynamic evolution of the system, accounting for the time dimension, whereas many other modelling approaches provide simply “snapshot” of the system state. Thirdly, both SDM and FCM allow to integrated different kinds of knowledge and data. Specifically, their capability to enable the integration between stakeholders’ perceptions and knowledge, and data-driven knowledge were used in WP3 activities in the NAIAD demos.



As further discussed in the text, the integrated models were used in NAIAD for exploring different management scenarios and, thus, for exploring the consequences of different set of alternative strategies, i.e. combination of NBS and socio-institutional actions.

Several experiences were carried out in different NAIAD demos using integrated modelling tools, in order to define a bottom-up procedure for co-designing NBS and for supporting their assessment. The basic idea behind the proposed approach is to focus on the identification, analysis and modelling of the co-benefits production, which is the key value added of NBS with respect to traditional grey infrastructures. The rationale of the proposed approach is the development of a sequence of individual and collective activities that should support assessing the effectiveness of strategies (i.e. a measure of a combination of multiple measures) in the production of the high-ranked benefits and co-benefits according to local stakeholders. The key advantage and element of innovation lies in the effort of proposing a solid procedure for eliciting and structuring local knowledge, collectively building a vision of the system under investigation, and simulating the effects of the most relevant scenarios.

These experiences contributed to highlight that, as already emphasized in a few recent scientific papers, although there are relevant positive effects of NBS on risk reduction and climate change adaptation, their adoption is still limited by several elements of uncertainty and multiple barriers. There is therefore a need to promote their introduction and mainstreaming using the available knowledge, while further exploring how open challenges and issues might be faced and overcome. Besides some technical barriers (e.g. the uncertainty on the long-term effectiveness of NBS, the limited availability of knowledge on the hydrologic response of some measures, etc.), the role of socio-institutional barriers is indeed becoming increasingly relevant. More specifically, the NAIAD approach is oriented to overcome some of the existing barriers to NBS implementation (e.g. institutional, legal, managerial, political, monetary and social) starting from the analysis of the multi-functionality of NBS: valuing their capability to provide several different benefits to multiple stakeholders and to meet different strategic objectives is indeed central. Identifying all the benefits that can be produced for different beneficiaries as well as the potential trade-offs, could support the development of a shared understanding and a negotiated set of values, thus leading communities and decision-makers to be more inclined to support implementation. However, since NBS implementation involves a multiplicity of stakeholders with their individual objectives, a specific risk perception and a different problem understanding, suitable tools need to be used to support investigating the potential impacts, to facilitate a dialogue, aligning divergences and promoting the social acceptance.



In this direction, the conceptual approach described in the following was used and implemented (with some specificities) in several NAIAD Demos. This approach has basically a threefold objective. Firstly, to analyze and value a diversity in frames and problem perception, focusing both on the risk perception and on the production of co-benefits. This can offer opportunities for innovation and promote the development of creative solutions, since a certain degree of ambiguity is desirable to foster the collaborative work needed to enable innovation. Secondly, going beyond the potential effect of ambiguity as a source of discrepancies or conflicts in a group, to build a shared view of the system, of the main objectives for the area and to select suitable strategies. These two objectives are reflected by the two phases (*'Divergent'* and *'Convergent'* respectively) that are identified in the following Figure 1 within the **'Qualitative Modelling Phase'**. Thirdly, to build a quantitative model capable to simulate scenarios connected to the implementation of one or multiple measures together, checking their effectiveness in the production of the selected benefits and co-benefits. The **'Quantitative Modelling Phase'** is performed with the purpose of building a more detailed model, based on an integrated collective analysis, and oriented to aid the development of scenarios to support collective actions.

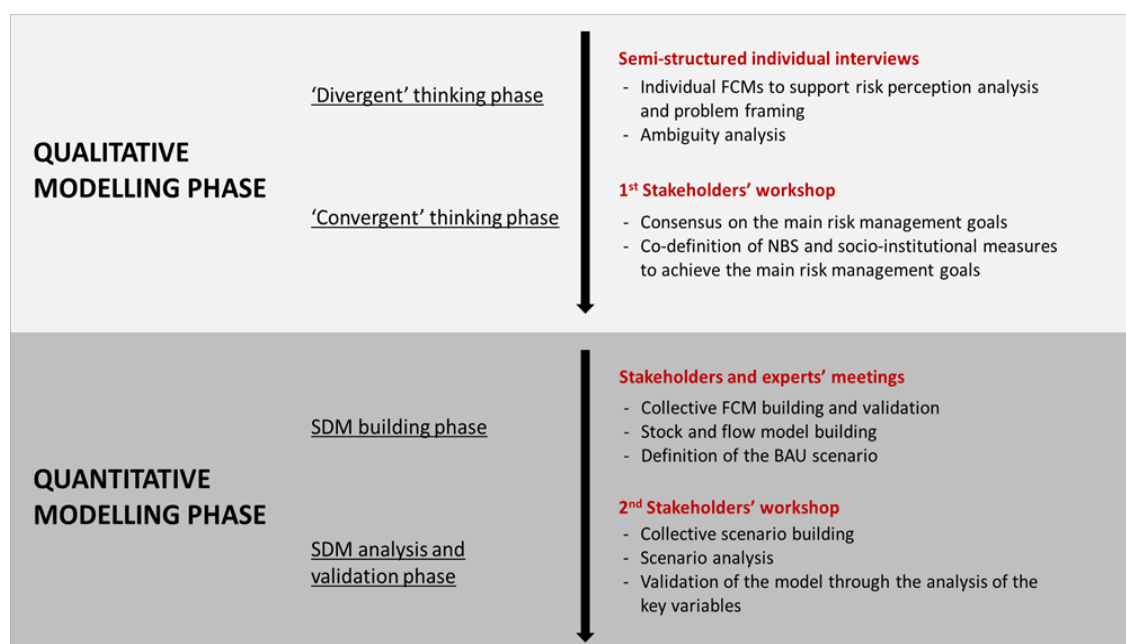


Fig. 1 Overview of the proposed framework



More specifically, the ‘qualitative modelling phase’, which is described in further details in (Santoro et al., 2019 and in the **D3.1**) relies on semi-structural individual interviews with key stakeholders, identified using a snowballing technique. Basically, the individual interviews are oriented to perform an individual problem analysis, and the results are then structured using FCMs, a formal way to represent conceptual models. FCMs are symbolized by a bidirectional graph of nodes (i.e. variables or concepts) and causal connections, and allow to investigate how people perceive a given system in terms of key concepts and mutual influences. A polarity and a (fuzzy) weight is assigned to every connection. Following the basic principles of network theory, an FCM can be translated into an adjacency matrix, and some measures of connectivity can be computed as well. For example, the use of the Centrality Index (CI) is used to define how central a variable is in the individual mental model, simply computing the number of incoming and outgoing connections. The following Fig. 2 proposes an example of FCM, along with the value of the CI for the main variables.

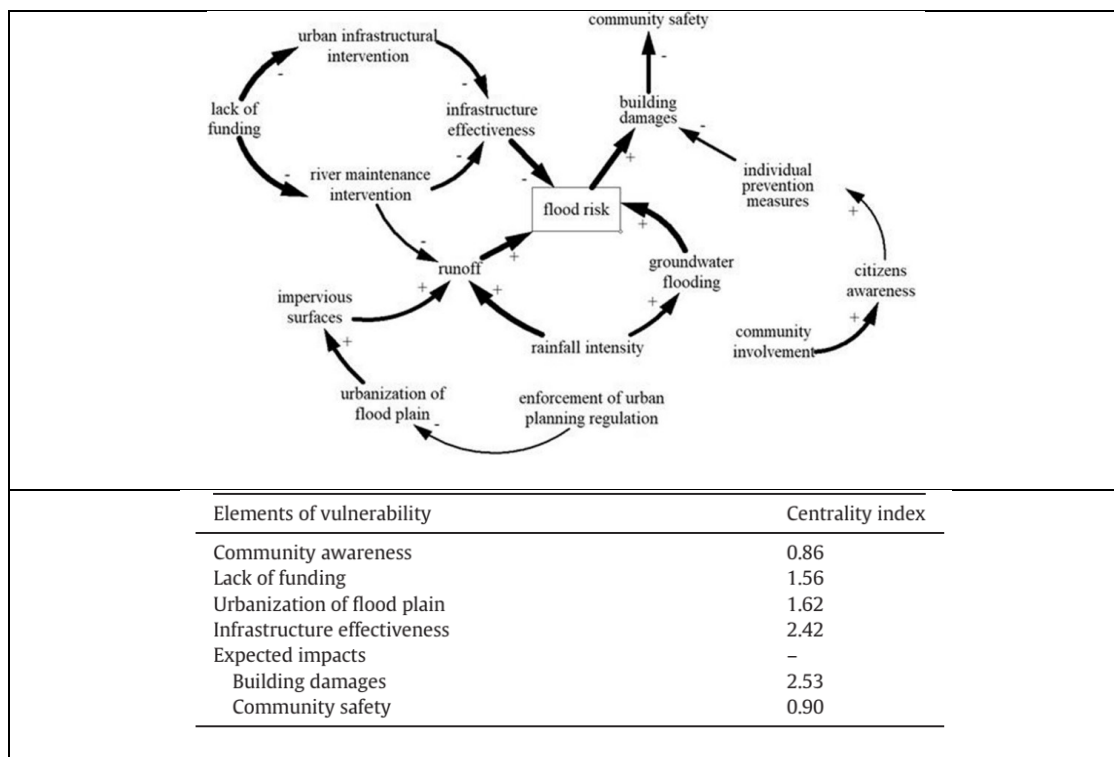


Figure 2. a) An example of FCM derived from an individual interview; b) analysis of the FCM using the Centrality Index



The FCM thus provide a synthesis of the mental model of each stakeholder. The comparison of multiple FCMs and related measures thus allows analyzing similarities and differences in the perceptions of different groups of stakeholders. More specifically, the Ambiguity Analysis can be carried out on individual FCMs, using specific metrics (such as the CI), in order to highlight similarities and differences among stakeholders' risk perceptions. The CI is coupled with another measure (i.e. the impacts degree, which is calculated checking the effect of each variable in a simplified scenario analysis) in order to estimate the 'importance degree', which provides a global assessment of the relevance of every variable. This step is crucial in the analysis of stakeholders' risk perception and allows also identifying the main vulnerabilities of the system (e.g. in the Glinscica DEMO, both the lack of institutional cooperation and the low level of implementation of the urban planning). A simple example is proposed in the following Table 1, which provides a simple comparison between two stakeholders in the Glinscica DEMO.

Table 1. Results of the Ambiguity Analysis for two stakeholders in the Glinscica DEMO

Decision actor	Variable	Centrality degree (index)	Impacts degree	Importance degree
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
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

The first phase of analysis, which is focused on the analysis of differences and individual problem understanding, is then followed by the 'convergent' thinking phase, which finally aims at building a shared model of the system and at reaching consensus on the main objectives. This step required organizing a workshop (Figure 3), with a twofold purpose: i) to reach consensus on the main goals of the risk management strategies, i.e. the main benefits and co-benefits to be



produced in the area; ii) to co-define the most suitable NBS for achieving the selected benefits and co-benefits. This phase need clearly that individual risk perception is not neglected. In order to keep track of the differences in risk perception, all the elements mentioned by the stakeholders were included in the analysis, and all participants were requested to provide individual inputs using a five-points Likert scale (i.e. 5 = very important, 4 = important, 3 = fairly important, 2 = slightly important, 1 = not important). The individual inputs were collected and aggregated, and the obtained then discussed by the participants in order to achieve consensus. The results of this phase were used in the discussion concerning the selection of the most suitable NBS, grey and of solutions to be implemented in order to achieve the above mentioned goals. Catalogues of potentially suitable NBS and grey solutions were created in advance through an interaction with local experts to facilitate the discussion. In this case as well, participants were required to provide individual scores for each of the three sets of measures. The aggregated ranking was then challenged in a group discussion. In general this debate provided several useful insights into the Demos, supporting on the one hand the identification of a shared view of the situation (in terms of objectives, elements of vulnerability, and potential barriers) and, on the other hand, the identification of a common strategy. Interestingly, the stakeholders showed a tendency to neglect grey solutions, focusing most of the discussion on the advantages of reasonably integrating NBS with socio-institutional measures.

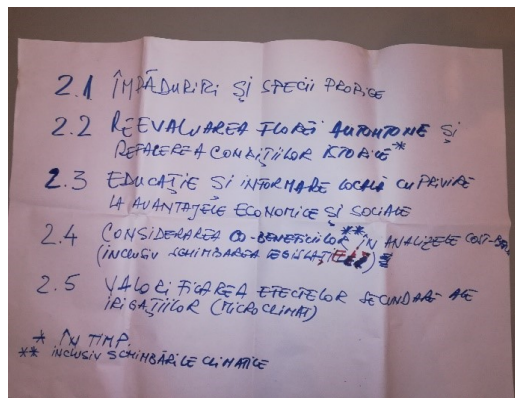


Figure 3. Group discussion (and some results of the exercises) for the identification of benefits/co-benefits and suitable NBS in the Lower Danube Demo

Afterwards, a process of aggregation of the multiple FCMs is performed. This represents a key step for moving from the qualitative to the quantitative modelling phase, and the basic step for building the stock and flow model. Several methods can be used for the FCMs aggregation,

which is not straightforward, particularly considering the ambiguity and the differences in problem framing that emerged in the 'divergent thinking'. In the NAIAD Demos, instead of performing directly an additive method, stakeholders were invited to construct an aggregated map during a participatory exercise, in order to limit potential inconsistencies and to facilitate the discussion. The process started, with the support of the analysts, merging similar variables (e.g. the same concept expressed using different words). Then, a discussion between the stakeholders is activated to draw the weighted connections among the variables. Stakeholders, during this phase, has the opportunity to add specific variables and connections that can be relevant according to their knowledge and specific expertise. Once the global structure is collectively built, it is further discussed, and potential differences in problem understanding analyzed. In the end, a collective FCM results, which is useful for the identification of key variables and relationships to include in the quantitative model. The following Figure 4 proposes the resulting aggregated FCM for the Potelu area (Lower Danube demo).

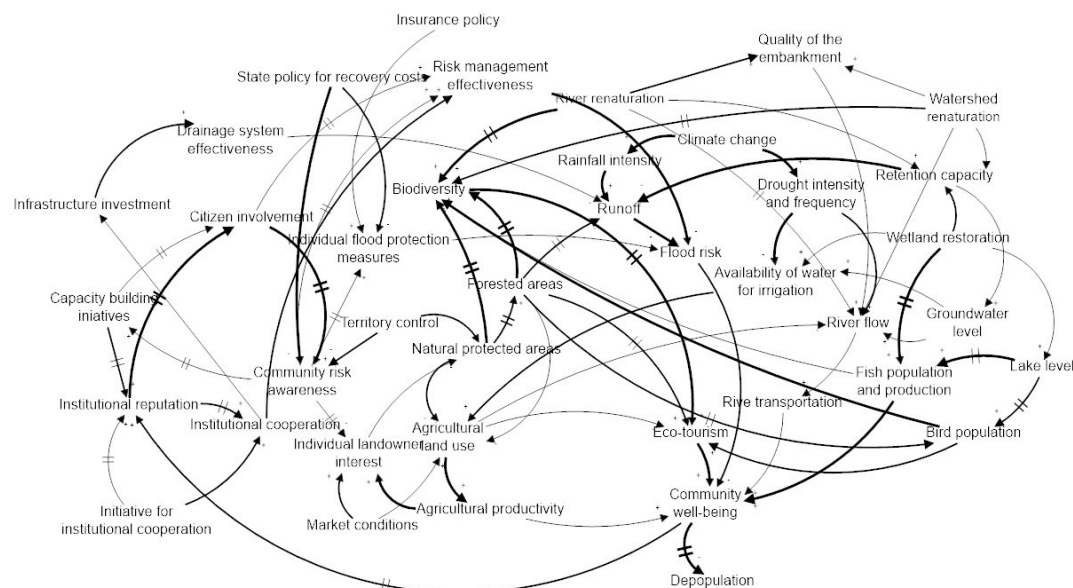


Figure 4. Aggregated FCM in the Potelu area (Lower Danube Demo).

The aggregated FCMs were used also for a simplified scenario analysis, oriented to the dynamic assessment of potential trade-offs in co-benefits production. Prior to use the aggregated FCM for simulating the dynamic of a system due to the implementation of NBS, some methodological issues need to be addressed. The most important one concerns the inclusion of time and delays



in the FCM scenario simulation. NBS require time for being effective, and different co-benefits can be produced at different time steps. Therefore, in order to be used for detecting and analyzing trade-offs due to co-benefits production, FCM should be capable to simulate the dynamic evolution of the system variables accounting for different time lags and delays. This represents a limit of the traditional approaches for FCM development, as pointed out by several authors (e.g. Jetter & Kok, 2014; Kok, 2009). Traditional FCM allows only a semi-quantitative analysis of the temporal dynamics. The output of FCM shows the values of the variables after a number of iterations, which cannot be directly translated into time steps, unless the FCM is characterized by processes that are assumed to act at the same time scale. This means that traditional FCM does not allow to consider delays in the connections among different variables. Moreover, the number of iterations it takes for the system to settle down cannot be interpreted as the time it takes the real-world system represented by the FCM to reach a quasi-stable state (Jetter & Kok, 2014).

In order to overcome the above mentioned drawbacks, this work assumes that delays can be introduced in the FCM by allowing changes in the adjacency matrix. The elements of this matrix represent the strength of the connections among pairs of variables. In traditional FCM, the adjacency matrixes are supposed to be constant. The edges connecting variables are characterized by two elements, i.e. the polarity and the weight, that are assumed to be invariable over time. In this work, we assumed that both the polarity and the weight can change over time, accounting for the expected dynamic of the causal connections in the real world.

For sake of clarity, let us consider two variables of a hypothetical FCM – i.e. “level of the lake” (variable A) and “biodiversity” (variable B). In a traditional FCM, the causal connection between these variables would be positive – the increase of A would lead to the increase of B – and characterized by a constant weight, e.g. 0.8. Therefore, the variable A would start affecting the variable B at the time step 0, and the strength of this influence will not change. In a model closer to the real world, the influence of A over B would change in time because of the processes influencing the biodiversity increase due to the lake level. In order to cope with the dynamic nature of the causal connections among variables, three different adjacency matrixes were developed. The matrixes describe the strength of the causal connections at three-time steps, i.e. short term, medium term and long term. A hypothetical example can illustrate the developed procedure for integrating time into dynamic FCM. Let us consider three variables – A, B and C, with the initial state vector $A = (1, 0, 0)$ and the following adjacency matrixes:

$$\text{Short term } E_s = \begin{pmatrix} 0.0 & 0.0 & 0.0 \\ -0.2 & 0.0 & 0.3 \\ 0.7 & 0.0 & 0.0 \end{pmatrix}$$



$$\text{Medium term } E_m = \begin{pmatrix} 0.0 & 0.0 & 0.0 \\ 0.4 & 0.0 & 0.3 \\ 0.2 & 0.0 & 0.0 \end{pmatrix}$$

$$\text{Long term } E_l = \begin{pmatrix} 0.0 & 0.5 & 0.0 \\ 0.6 & 0.0 & 0.8 \\ 0.7 & 0.0 & 0.0 \end{pmatrix}$$

Afterwards, the FCM scenario is simulated by implementing three times the FCM formula (Kosko, 1986):

$$\text{State vector in the short term: } V_s = A \times E_s = A \times \begin{pmatrix} 0.0 & 0.0 & 0.0 \\ -0.2 & 0.0 & 0.3 \\ 0.7 & 0.0 & 0.0 \end{pmatrix}$$

$$\text{State vector in the medium term: } V_m = V_s \times E_m = V_s \times \begin{pmatrix} 0.0 & 0.0 & 0.0 \\ 0.4 & 0.0 & 0.3 \\ 0.2 & 0.0 & 0.0 \end{pmatrix}$$

$$\text{State vector in the long term: } V_l = V_m \times E_l = V_m \times \begin{pmatrix} 0.0 & 0.5 & 0.0 \\ 0.6 & 0.0 & 0.8 \\ 0.7 & 0.0 & 0.0 \end{pmatrix}$$

In the NAIAD demos, the three adjacency matrixes were developed accounting for the stakeholders' problem understandings. Stakeholders were asked to detect and define the main delays in the FCM. Firstly, they identified the connections subjected to changes in time. These arcs were reported with the delay symbol in the FCM. Secondly, a group discussion was organized in order to define the weights to be assigned to those arcs in the three time steps, i.e. short, mid and long term. The three adjacency matrixes were developed accordingly.

Different risk management scenarios were simulated, and different stakeholders were asked to discuss the potential impact of selected measures on the most relevant variables. As discussed in NAIAD deliverable D6.3, stakeholders were required to combine NBS and socio-institutional actions from two pre-defined sets of actions (developed in the earlier phases of NAIAD implementation). Table 2 shows the two sets of measures used for simulating the risk management scenarios.

Table 2: Integration between NBS and soft actions, as discussed by the stakeholders during the Craiova workshop.

Set of actions	NBS	Soft measures
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Set 1	Wetland restoration	Institutional cooperation
	River renaturation	State policy for recovery costs
		Territory control
Set 2	Retention areas	Infrastructure maintenance and development
	Reforestation	Capacity building initiatives
		Insurance policy

A comparison between two scenarios, produced using FCMs in the Lower Danube Case study, is proposed in the following Figure 5.

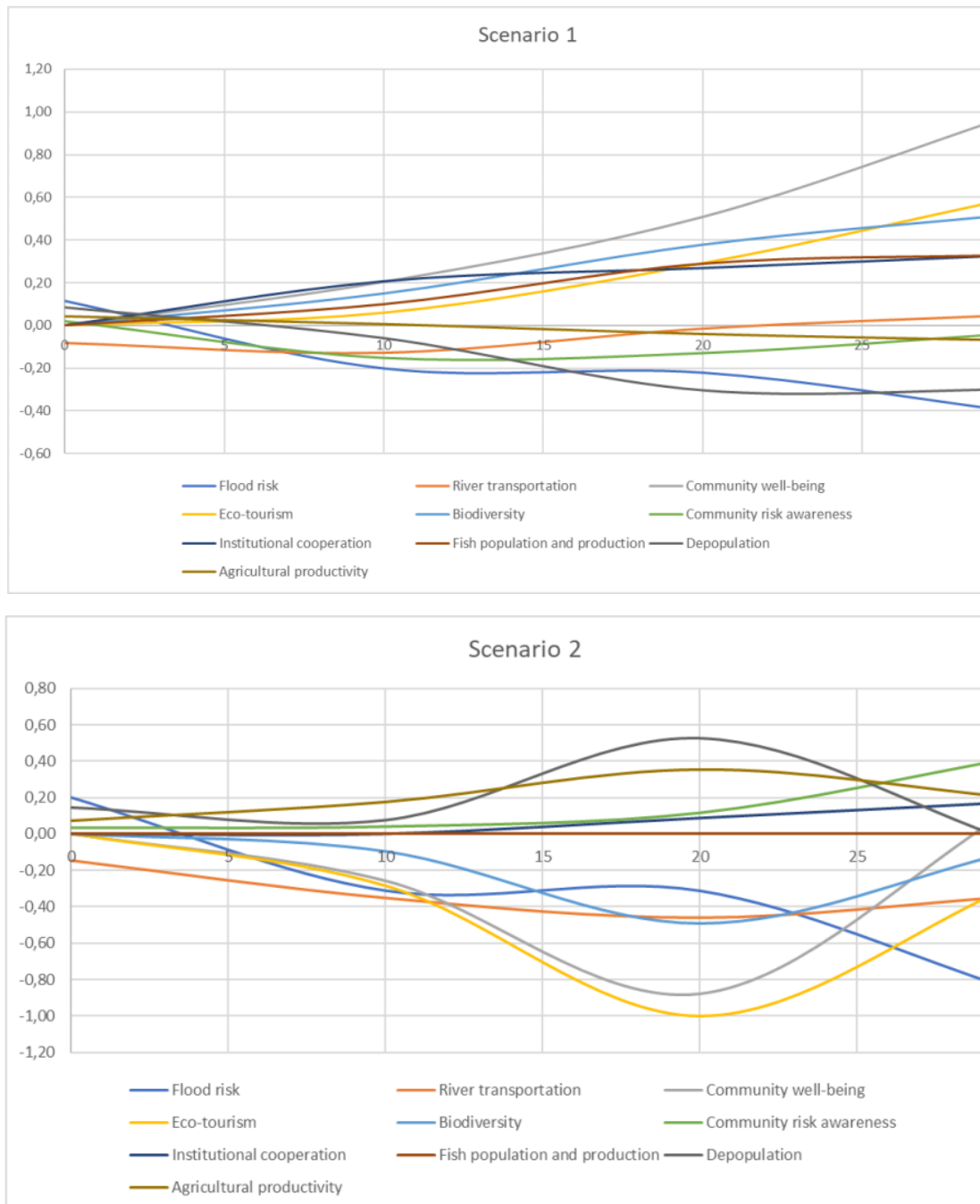


Figure 5 a) and b): co-benefits evolution in the two risk management scenarios selected by stakeholders. The Y-axis represents the fuzzy values of the FCM variables.



Figure 5 shows the positive impact of the measures implemented in scenario 1 on the community-well-being. This is mainly due to the expected increase of the biodiversity and, therefore, of the eco-tourism. The decrease of the agricultural productivity, caused by the increase of the natural protected areas, will not affect the community well-being. According to the stakeholders' knowledge, the current agricultural production system – i.e. characterized almost entirely by one big producer, with small repercussion the local employment rate. The river transportation decreases in the early phase of the scenario simulation and, then, slightly increase. This is mainly caused by climatic conditions, which are supposed to remain negative for the whole scenario – that is, high drought frequency – and due to limited effects of the selected NBS on the river flow. Figure 5b shows the negative impacts of the selected actions on measures on the co-benefits connected to the biodiversity and eco-tourism. This is mainly due to the expected increase of the cultivated lands, caused by the lack of territory control and the increase of water availability for irrigation purposes. In the long terms – i.e. after 20 years – this dynamic evolution will change, according to the stakeholders' problem understanding. The inflection point in the diagram is mainly due to the change in the weight of the causal connection in the long-term adjacency matrix. Specifically, the stakeholders described a change in the weight of the causal connections in the long-term. Specifically, the increased institutional cooperation will have a higher impact on the implementation of the policies for the creation and maintenance of protected natural areas. This, in turn will have an increasing positive impact on the biodiversity and, thus, on biodiversity. The lack of territory control and the implementation of capacity building initiatives will cause an increase of the community risk awareness.

Table 3: Simulated values for the co-benefits defined by the Dabuleni Municipality.

Co-benefits	Weight	FCM scenario		
		Short term	Medium term	Long term
Institutional cooperation	High	0,21	0,27	0,33
Agricultural productivity	Medium	0,01	-0,04	-0,07
River transportation	High	-0,13	-0,02	0,05
Community well-being	High	0,02	0,51	1,00

The results obtained by the FCM were, then discussed by the stakeholders in order to support the selection of the most suitable combination of NBS and socio-institutional actions.



In other NAIAD demos, a SDM was developed for supporting the NBS co-designing and assessing NBS. SDM can be interpreted as an evolution of FCM. Its structure can be developed as a set of mathematical expressions governing the system, incorporated via flow diagrams and finally transformed using a simulation environment. This step is crucial to fully translate the verbal descriptions of individual problem understanding into a working simulation model of the system, supporting the mathematical computation of the outputs. FCM's variables and causal relationships are translated into the common SDM sets: stocks (quantities subjected to accumulation, either physical or not), flows (rates of changes, either increasing or depleting stocks), converters (intermediary variables that can help describing the processes of the model), connectors (interrelationships among various elements in the model which can reflect cause-and-effect rules). The model built for the Glinscica Demo is represented in the following Figure 6.

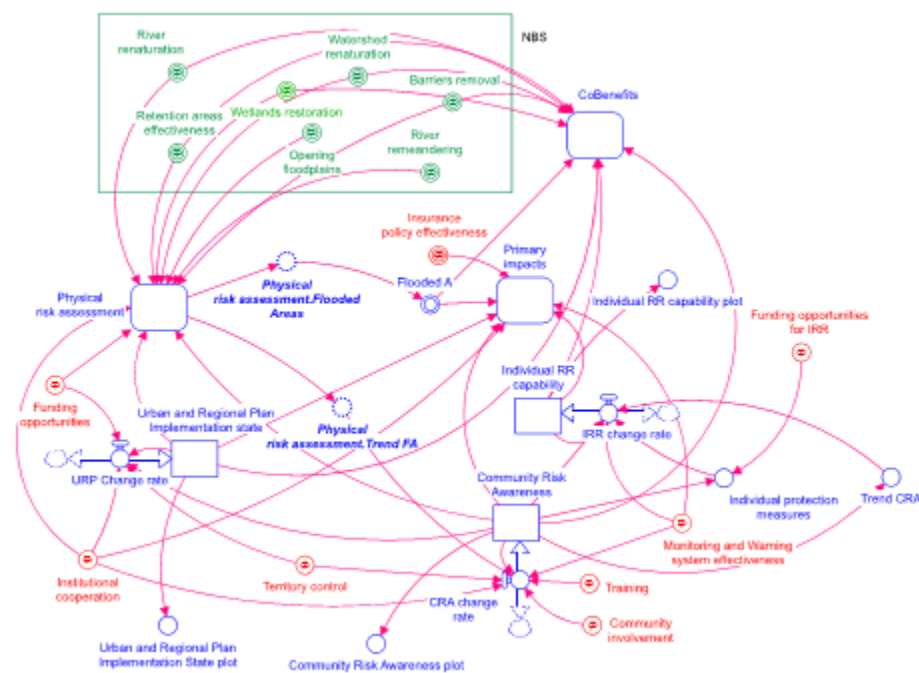


Figure 6. Overview of the stock and flow model built in the Glinscica Demo.

On the basis of the identified variables, and their causal dependencies, hypotheses are formulated on the mathematical functions and parameters, integrating multiple sources of information, mainly expert consultation, scientific/grey literature and field surveys. Lastly, the



SDM needs validation, using both sensitivity runs to check the consistency of model structure and equations, and stakeholders' judgement. All the stakeholders involved in model building should be asked to support model validation, each one referring to the specific sub-set of variables on which he/she felt more qualified or entitled to contribute. This step was performed using both individual activities and participatory exercises (during the 2nd workshop). This workshop aimed also to develop different risk management scenarios. The first session introduced and discussed a glossary, some examples of successful implementation of NBS across Europe and few indicators, their role and how they can be generated – specific reference was made to the EKLIPSE framework. The second session focused on the co-design of three scenarios for improved risk management using both the NBS and the socio-institutional (S-I) measures. Following a general presentation of the SDM, stakeholders were asked to collectively select a combination of measures for each scenario (at least 1 NBS measure and at most 5 S-I measures altogether). The scenarios were simulated, and the results collectively discussed considering the variation of the main variables of the SDM (specifically benefits/co-benefits) in comparison to the BAU scenario. Further details on the 'convergent thinking phase' and on the quantitative modelling, along with more specific details for the single DEMOs can be found in the **D3.3**.



Figure 7 shows the dynamic evolution of the co-benefits assessed through the SDM simulation.

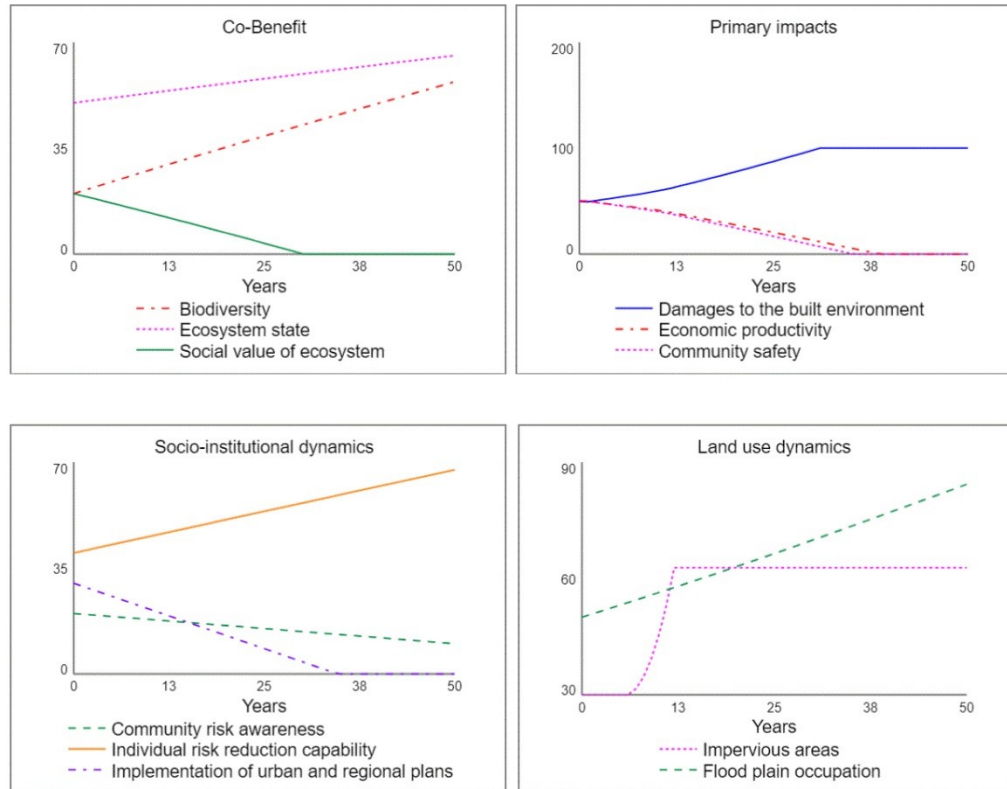


Figure 7: SDM simulation for co-benefits assessment. The X-axis represents the time in year. The Y-axis shows the value of the variable in the SDM. Variables can assume a value between 0 and 100.

3. RISK PERCEPTIONS AND CO-BENEFITS IDENTIFICATION AND VALUATION: TRADE-OFFS AND CONFLICTS

Evidences demonstrated the role that co-benefits assessment and valuation could play in enhancing NBS social acceptance. In order to be preferred over grey solutions for coping with water-related risks, it is increasingly important to collect evidences of their multiple benefits (Frantzeskaki, 2019; Raymond et al., 2017; Alves et al., 2019). Most of the scientific efforts for demonstrating the NBS effectiveness and for improving the measurability of the produced co-benefits, focuses on the development of integrated sets of indicators, e.g. distribution of public spaces, recreation or cultural value, openness of participatory process, etc. (e.g. Calliari, et al., 2019; Kabisch et al., 2016; Raymond et al., 2017). For instance, Kabisch et al., 2016 and Xing et al., 2017 examined indicators of NBS effectiveness at the urban scale, although with a level of



abstraction that does not support a comparison with different alternatives. A guidance on NBS for flood risk management, as alternative or complementary to conventional engineering measures, was proposed by the World Bank (2017).

Although the mentioned approaches have been implemented in monitoring and assessing NBS effectiveness, they have some limitations. Firstly, they have a limited capability to fully analyze the NBS potential for producing co-benefits (e.g. Kabisch et al., 2016), being limited to the analysis of a subset of impacts (mainly environmental) and rarely addressing the cross-sectoral ones. In particular, there are some aspects such as the socio-cultural, economic and ecosystem interactions, that require further consideration. Secondly, it should be considered that they are generally static, i.e. the analysis of NBS is performed assuming that both the NBS and the conditions in which they are set to operate (e.g. climate, urbanization, etc.) are immutable and not affected by any change (Calliari et al. 2019). Lastly, most of the existing frameworks are limited in terms of stakeholders' involvement, and, consequently do not support the management of the unequal distribution of the co-benefits' fruition among the different potential beneficiaries.

The activities carried out in the NAIAD demos were meant to facilitate the stakeholders' engagement in defining the expected co-benefits for NBS co-design. Contrarily to most of the commonly adopted approaches, aiming at defining the co-benefits once the NBS is designed, NAIAD refer to the stakeholders' preferences over the co-benefits as a way for leading the identification and design of the most suitable NBS to be implemented. This is because, during the early stages of NAIAD activities, we learned that co-benefits production is considered by the stakeholders as even more important than the reduction of water-related risks. Therefore, WP3 activities aimed at eliciting stakeholders' perception of the desirable co-benefits and to refer to these results for the co-design of the NBS. The existing differences in co-benefits perception among the involved stakeholders were accounted for, and a trade-off analysis among the different beneficiaries was carried out. The activities carried out in the demos aimed at: i) detecting and analyzing differences in stakeholders' values and perceptions of the multi-dimensional benefits; (ii) raising awareness of what situations may produce a trade-off with an understanding of why (and what) trade-offs could result from NBS implementation; and (iii) resolving potential conflicts over NBS implementation and co-benefits evaluation.

The following figure shows the different phases of the methodology implemented in the different demos.

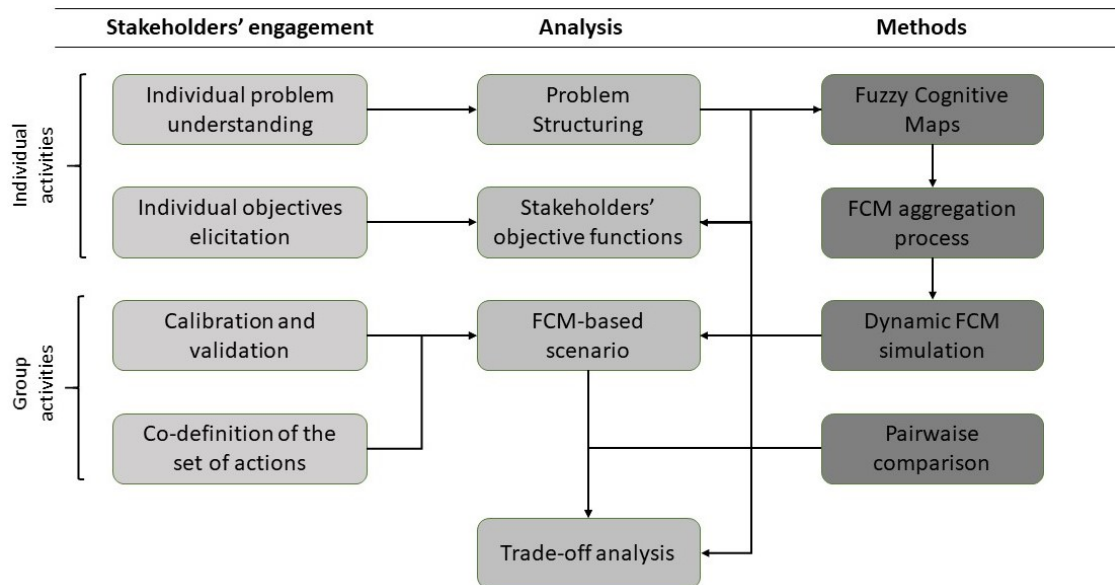


Figure 8. Different phases of the implemented methodological approach.

As shown in figure 8, the implemented approach combined stakeholders-driven activities with “table-work” for analysing the obtained results and inform the other phases of the stakeholders’ engagement process.

The work done in the NAIAD demos aimed at enhancing the potential richness, diversity and complexity of the collected knowledge, rather than searching consensus among participants. Therefore, as already described in D3.1 (<http://naiad2020.eu/media-center/project-public-deliverables/>), a combination of individual and group activities were designed and implemented for eliciting, structuring and validating the stakeholders’ knowledge and perception. For a more detailed description of the method used for eliciting stakeholders’ risk perception and for developing individual FCM, a reader can refer to the NAIAD deliverable D3.1. In this work, it is worth mentioning that the semi-structured interviews were designed according to the mean-end approach. Namely, interviewees were required to describe the “risk-primary impacts-secondary impacts-vulnerability-measures” perceived chain of causality. Specifically, the interviews aimed at gathering their understandings about: (i) the main elements affecting the water-related risks at local level; (ii) the direct and indirect expected impacts; and (iii) the most important issues (social challenges) that need to be addressed in order to increase the effectiveness of the risk management actions and enhance the system conditions (Bain et al.,



2016). Finally, stakeholders were required to specify the expected roles of the NBS in reducing water-related risks and addressing the social challenges.

The collected knowledge was, hence, processed in order to obtain the individual FCM. Specifically, structural relationships forming the FCM topology were defined accounting for the causal assertions made by individuals. The sentences were broken down into specific categories, i.e. (i) cause variables; (ii) effect variables; and (iii) relationships type (Kim & Andersen, 2012). Table 3 shows the analysis of the stakeholders' argumentation, in order to detect the structural relationships.

Table 4: Examples of the analysis of the interviews for developing the structural relationships in the CM.

Quotes from the interviews	Cause variables	Effect variables	Relationship type
"Poor maintenance increases the flood risk due to the canal's effectiveness"	Canal maintenance	Canal effectiveness Flood risk	Positive Negative
"The urban elements affecting the intensity of flood risk are mainly the lack of urban planning and citizens' behaviour, producing unregulated settlements"	Urban planning Citizens' behaviour	Unregulated settlements Flood risk	Positive Negative

The expected impacts of NBS according to the stakeholders' problem understanding were assessed. The assumption here was that the NBS was considered effective by each individual stakeholder if its implementation caused a significant change in the value of the variables related to the most important benefits in the individual FCM. To this aim, the individual FCM were simulated activating the NBS variable in the FCM (Kok, 2009; Santoro et al., 2018). The change of the values of the most important FCM variables (i.e. those with a high centrality degree) due to the activation of the NBS allowed us to assess the expected NBS impacts (impact degree) according to the stakeholders' perception. Figure 9 shows the change of the values of the FCM variables due to the NBS activation. The results of the Lower Danube demo were used in this figure.

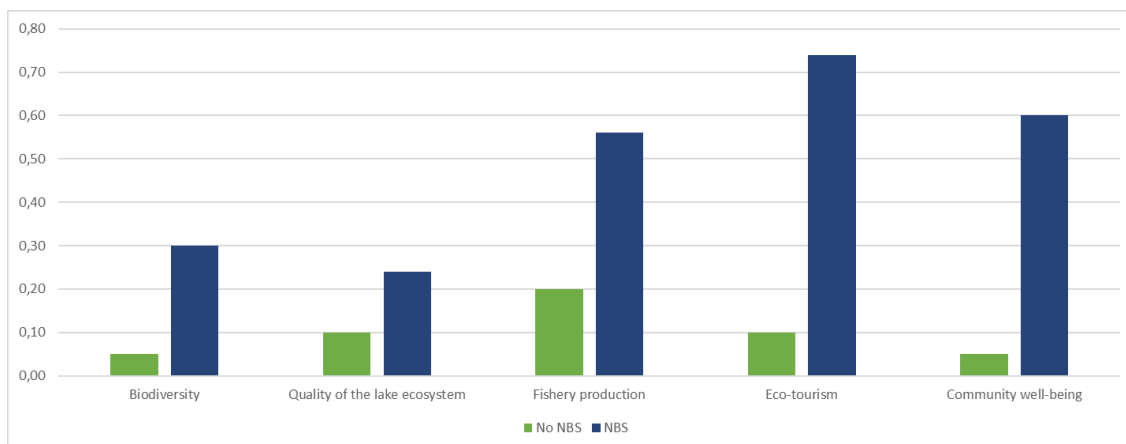


Figure 9: NBS impact on the FCM values.

The proposed approach assumes that a stakeholder attributes a high importance to a certain co-benefit if it plays a central role in his/her own problem perception – that is, if it is central in the CM – and if the NBS is expected to provoke a significant change in the state of the co-benefits variables in the stakeholder’s FCM.

The assessment of the importance degree allowed us to identify the key values in the stakeholders’ perceptions and, then, to define the most important benefits and co-benefits due to the implementation of the NBS. Referring to the value-focused thinking approach developed by Keeney (1992). The obtained values were transformed in objectives and, then, integrated in the stakeholders’ objective functions. For sake of clarity, the following table shows the results of the co-benefits identification for the Lower Danube demo.

Table 5. Stakeholders’ perceptions of the expected co-benefits to be produced through NBS implementation in the Lower Danube demo.

Stakeholder	Variable	Centrality degree	Impacts degree	Importance degree
Dabuleni Municipality	Institutional cooperation	High	Positive	High
	Agricultural productivity	Medium	Weakly Positive	Medium
	River transportation	High	Highly Positive	High
	Local development	Medium	Positive	High



Bistret Municipality	Institutional cooperation	High	Positive	High
	Community awareness risk	High	Weakly Positive	Medium
	Agricultural productivity	Medium	Weakly positive	Medium
	Community well-being	Medium	Positive	High
	River transportation	Medium	Weakly positive	Medium
	Tourism	Medium	Highly Positive	High
Calafat Municipality	River transportation	High	Positive	High
	Local development	Medium	Weakly Positive	Medium
Corabia Municipality	Community awareness risk	Medium	Positive	Medium
	Institutional cooperation	High	Positive	High
	Agricultural productivity	Medium	Weakly Positive	Medium
	River transportation	High	Positive	High
Rastul Vechi Municipality	Community awareness risk	Medium	Weakly Positive	Medium
	Agricultural productivity	Medium	Positive	High
	River transportation	Medium	Positive	High
Turnu Măgurele	Community awareness risk	Medium	Weakly Positive	Medium
	Institutional cooperation	High	Positive	High
	Biodiversity and ecosystem state	Medium	Weakly Positive	Medium
	Local development	Low	Positive	Medium
	River transportation	Medium	Highly Positive	High



	Community wellbeing	Medium	Positive	High
WWF Romania	Community risk awareness	High	Positive	High
	Institutional cooperation	High	Weakly Positive	Medium
	Lake ecosystem and biodiversity	Medium	Positive	High
	Rural eco-tourism	Low	Positive	Medium
Ministry of agriculture and rural development	Community risk awareness	Medium	Weakly Positive	Medium
	Agricultural productivity	High	Positive	High
	Fish production	Medium	Positive	High
Romanian National Agency for Fishing and Aquaculture (ANPA)	Fish production	High	Positive	High
	Biodiversity	High	Highly positive	High
	Community wellbeing	Medium	Positive	High
National Administration "Romanian Waters" (NARW)	River transportation	Medium	Positive	High
	Community well-being	Medium	Weakly positive	Medium
	Community risk awareness	High	Weakly positive	Medium

The importance degree in the table for each of the involved stakeholders was, then, used to assign them a weight. The stakeholders' objective functions were defined accounting for the importance degree assigned through the FCM analysis, as shown in the following equation. The additive form was assumed for assessing the objective function.

$$F(O)_i = \sum_{j=1}^n O_{ij} * W_{ij} \quad [1]$$

Specifically, $F(O)_i$ represents the objective function for the i-th stakeholder; O_{ij} is the value assumed by j-th objective due to the NBS implementation, and W_{ij} represents the weight of the



j-th objective in the i-th stakeholder's FCM. For instance, the objective of the WWF was to maximize the following function:

$$F(O)_{wwf} = CA * w_{CA} + IC * w_{IC} + AP * w_{AP} + LB * w_{LB} + FP * w_{FP} + ET * w_{ET}$$

In which *CA* represents the value of the variable "Community Risk Awareness" and *w_{CA}* represents its weight (i.e. importance degree) in the stakeholder's problem perception. The other elements in the equation represent the values of the remaining selected co-benefits and the associate weights. The same approach was implemented for defining the objective functions for the other stakeholders.

The stakeholders' objective function were used in WP3 for detecting and analysing trade-offs among stakeholders. In our work, a trade-off between two stakeholders can be detected if disparities exist in taking advantages from the co-benefits production due to NBS implementation. To this aim, the NBS impacts on the co-benefits were assessed simulating "what-if" scenarios referring to the integrated models, described in section 2. In WP3 activities, two kinds of model were developed in cooperation with WP5 and implemented in several demos, namely the Stock-and-flows model and the Fuzzy Cognitive Map. Both models are based on the system thinking approach, as described in section 2 of this document, and they are capable for simulating the dynamic evolution of the co-benefits production.

The introduction of the temporal dimension in simulating NBS effectiveness is of utmost importance. Most of the causal interactions included in the models and affecting the NBS effectiveness and co-benefits production described processes that evolve over time. As pointed out by Kabisch et al. (2016), one of the key knowledge gaps in assessing NBS effectiveness is related to the time scale of NBS implementation and co-benefits production. This is particularly true for the variables related to the natural system – e.g. biodiversity, bird population, forested areas, etc. – and the social system – e.g. community risk awareness, institutional cooperation, etc. NBS require time for being effective, and different co-benefits can be produced at different time steps. Some of the expected co-benefits can be produced in the immediate aftermath of the NBS implementation or even during the process of NBS design, whereas others can emerge in the long terms – e.g. ecosystem restoration and biodiversity increase. Neglecting the time scale of these processes could lead to erroneous and over-simplified results concerning the NBS effectiveness in producing co-benefits and, thus, in detecting and assessing trade-offs among different stakeholders.

The stakeholders' objective functions were calculated in different time steps, as showed in the following table.



Table 6. Simulated values for the co-benefits defined by the Dabuleni Municipality in the Lower Danube demo.

Co-benefits	Weight	FCM scenario		
		Short term	Medium term	Long term
Institutional cooperation	High	0,21	0,27	0,33
Agricultural productivity	Medium	0,01	-0,04	-0,07
River transportation	High	-0,13	-0,02	0,05
Community well-being	High	0,02	0,51	1,00

The values of the variable sin the FCM scenarios were used in this table. It is worth mentioning that FCM variable can assume values in the interval [-1; 1].

The extent to which a stakeholder benefits of the NBS co-benefits was assessed by comparing the desirable and the simulated – i.e. calculated through the use of the integrated models – values of the stakeholders’ objective function. The basic assumption here was that the closer these two values, and the more satisfied the stakeholder’s expectations. Stakeholders were asked individually to draw the desirable shapes for the variables connected to the co-benefits. In order to facilitate the stakeholders in carrying out this task, supporting material was prepared referring to the most typical modes of system behavior, as explained by Vennix et al. (1996). The meaning of the fundamental modes (exponential growth, goal-seeking and oscillation), of the non-linear interactions of the fundamental modes (S-shaped growth, Growth with overshoot, Overshoot and collapse), and of the equilibrium and randomness were simplified and described to the stakeholders. Starting from these exemplary functions, the stakeholders were asked to describe the desirable evolution of the co-benefits variables.

In order to facilitate their task, three main time steps were considered, i.e. short, medium and long term. Considering that the NBS scenarios were based on 30 years’ simulation, we assumed that short term was about 10 years, medium in 20 years, and long in 30 years. Figure 10 shows the expected evolution of the co-benefit “Community risk awareness” according to the WWF in the Lower Danube demo.

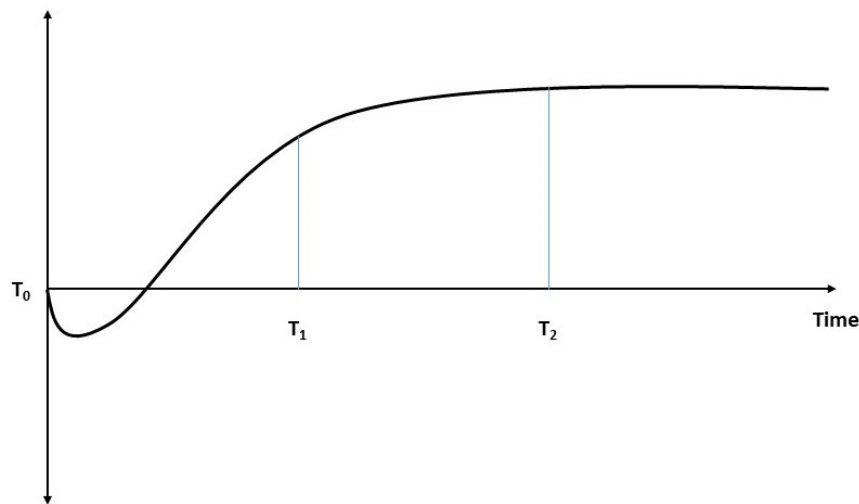


Figure 10. dynamic evolution of the “Community Risk Awareness” according to the WWF in the Lower Danube demo.

As shown in Figure 10, the WWF was aware that raising risk awareness in the local community required time. Therefore, in the early phase of the NBS implementation, the variable decreases, according to the current trend. In the medium and long term, WWF expected to register an increase in the risk awareness.

Similar inputs were collected by the other stakeholders concerning their perception of the dynamic evolution of the selected co-benefits. The collected inputs were, then, used for detecting and analysing the trade-offs, as described further in the text. It is worth mentioning that, in few cases, it was not possible to draw the graph of the desirable dynamic evolution of the co-benefits interacting directly with the stakeholders. In these cases, the graphs were solicited using the results of the interviews and, then, validated prior to be used for the trade-offs analysis.

In order to assess NBS effectiveness in producing co-benefits and to detect trade-offs among different stakeholders, risk management scenarios were developed using the integrated models, either the SDM or the FCM. In this work, scenario was defined as a quantitative description of the future conditions of the studied system, told through the values of the SDM or FCM variables, offering an internally consistent and plausible explanation of how events unfold over time (Kok, 2009). SDM or FCM simulation models were used to create “what if” stories about the future. Alternative scenarios were developed, reflecting the knowledge of the



involved stakeholders, and shaped by different combinations of input variables (Jetter & Kok, 2014). The simulated outcomes were used to describe the different scenarios.

A two-steps methodology was implemented. In the first step, the comparison among the objective functions in the desirable scenario and the NBS-based scenario was carried out for each stakeholder. The table 6 shows the results of this step.

Table 7. Assessment of the perceived benefit for the i-th stakeholder.

Time	Desirable scenario	NBS scenario	Perceived benefit
1	$F(Od)_i^1$	$F(Os)_i^1$	$D_i^1 = F(Os)_i^1 - F(Od)_i^1$
2	$F(Od)_i^2$	$F(Os)_i^2$	$D_i^2 = F(Os)_i^2 - F(Od)_i^2$
3	$F(Od)_i^3$	$F(Os)_i^3$	$D_i^3 = F(Os)_i^3 - F(Od)_i^3$
...	...	...	...
n	$F(Od)_i^n$	$F(Os)_i^n$	$D_i^n = F(Os)_i^n - F(Od)_i^n$

If the difference $F(Os)_i^j - F(Od)_i^j$ is positive, then the i-th stakeholder will perceive a benefit due to the implementation of the NBS. Otherwise, a dis-benefit will be perceived.

In the second step, a pairwise comparison among the perceived benefits by each stakeholder will be carried out at each time step. Assuming that n stakeholders were involved in the exercise, the following matrix was developed for the j-th time step.

Table 8. Pairwise comparison among the benefits perceived by the different stakeholders at time j.

	S_1	S_2	...	S_n
S_1	-	$ D_1^j - D_2^j $	...	$ D_1^j - D_n^j $
S_2	$ D_2^j - D_1^j $	-	...	$ D_2^j - D_n^j $
...	..	...	...	...
S_n	$ D_n^j - D_1^j $	$ D_n^j - D_2^j $	...	-



The table 7 shows the distance among the perceived benefits for the involved stakeholders, which was considered in this work as a measure of the trade-off between pairs of stakeholders. This analysis allowed to detect potential conflicts due to the NBS implementation, and to define the time steps when these conflicts might emerge. The basic assumption is that the higher is distance and the more likely is the conflict due to the trade-off.

Figure 11 shows the comparison between the desirable and the simulated objective functions for the different stakeholders involved in the Lower Danube demo.

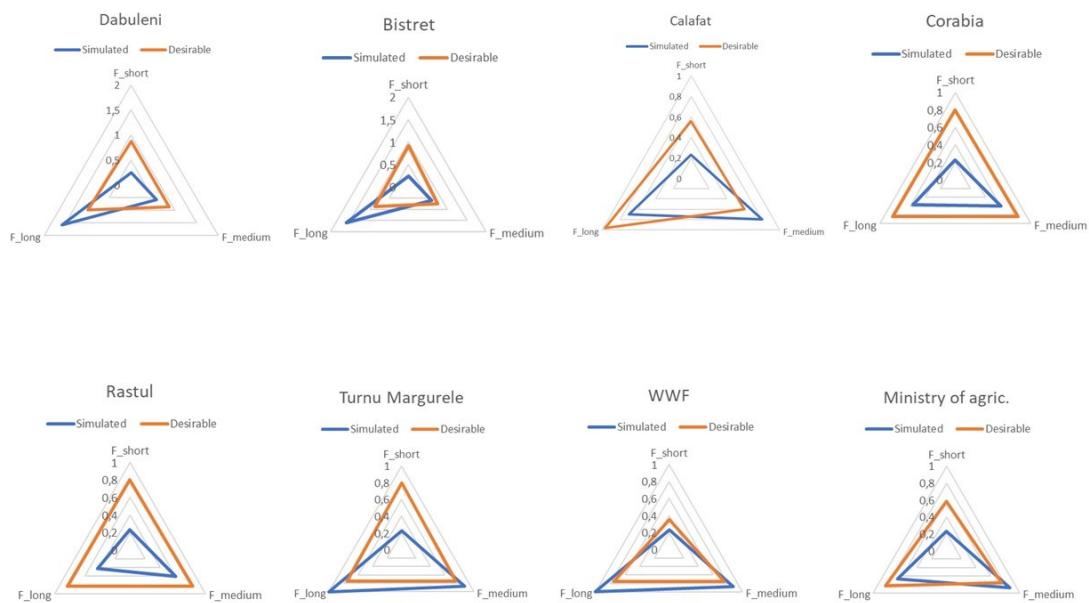


Figure 11: Comparison between the stakeholders' objective functions in the simulated and desirable scenarios.

The Lower Danube example shows the importance of accounting for the temporal dimension in assessing the co-benefits production and in detecting the trade-offs. Most of the involved stakeholders perceived a dis-benefits in the short term. This is mainly because stakeholders over-estimate the effectiveness of the implemented set of actions in producing the co-benefits.

In many cases, the stakeholders perceived a high benefit from the strategy implementation in the long term because of the positive impact of the implemented strategy on the eco-tourism and community well-being. Table 8 a), b) and c) show the pairwise comparison among the stakeholders' perceived benefits in the short, medium and long term. The distance between two stakeholders was considered here as a measure of the potential trade-off.



Table 9a. Pairwise comparison among the stakeholders' perceived co-benefits in the short term.

	Dabuleni	Bistret	Calafat	Corabia	Rastul	Turnu Magurele	WWF RO	MARD
Dabuleni	-	0,05	0,29	0,05	0,05	0,07	0,50	0,27
Bistret	0,05	-	0,34	0,34	0,10	0,10	0,55	0,32
Calafat	0,29	0,34	-	0,24	0,24	0,56	0,19	0,02
Corabia	0,05	0,34	0,24	-	0,00	0,02	0,45	0,12
Rastul	0,05	0,10	0,24	0,00	-	0,02	0,45	0,12
Turnu Magurele	0,07	0,10	0,26	0,02	0,02	-	0,47	0,14
WWF RO	0,50	0,55	0,19	0,45	0,45	0,47	-	0,23
MAFDF	0,27	0,32	0,02	0,12	0,12	0,14	0,23	-

Table 9b. Pairwise comparison among the stakeholders' perceived co-benefits in the medium term.

	Dabuleni	Bistret	Calafat	Corabia	Rastul	Turnu Magurele	WWF RO	MARD
Dabuleni	-	0,12	0,48	0,05	0,05	0,40	0,40	0,40
Bistret	0,12	-	0,36	0,07	0,07	0,28	0,28	0,28
Calafat	0,48	0,36	-	0,43	0,43	0,02	0,08	0,08
Corabia	0,05	0,07	0,43	-	0,00	0,35	0,35	0,35
Rastul	0,05	0,07	0,43	0,00	-	0,35	0,35	0,35
Turnu Magurele	0,40	0,28	0,02	0,35	0,35	-	0,00	0,00



WWF RO	0,40	0,28	0,08	0,35	0,35	0,00	-	0,00
MARD	0,40	0,28	0,08	0,35	0,35	0,00	0,00	-

Table 9c: Pairwise comparison among the stakeholders' perceived co-benefits in the long term.

	Dabuleni	Bistret	Calafat	Corabia	Rastul	Turnu Magurele	WWF RO	MARD
Dabuleni	-	0,12	0,86	0,86	0,99	0,34	0,36	0,75
Bistret	0,12	-	0,74	0,74	0,87	0,22	0,24	0,63
Calafat	0,86	0,74	-	0,00	0,23	0,53	0,55	0,11
Corabia	0,86	0,74	0,00	-	0,23	0,53	0,55	0,11
Rastul	0,99	0,87	0,23	0,23	-	0,65	0,67	0,24
Turnu Magurele	0,34	0,22	0,53	0,53	0,65	-	0,02	0,41
WWF RO	0,36	0,24	0,55	0,55	0,67	0,02	-	0,43
MARD	0,75	0,63	0,11	0,11	0,24	0,41	0,43	-

As shown in these tables, the trade-offs are quite small in the short term. Most of the potential conflicts can be detected in the long term, and involve mainly the stakeholders that assigned a high value to the agricultural productivity.

4. SOCIAL NETWORK ANALYSIS AND NBS ACCEPTANCE

As already described previously, differences in risk perceptions and co-benefits valuation could lead to conflict. This section describes the activities carried out in one of the NAIAD demos, namely Medina del Campo, and aiming at reducing the level of conflicts among stakeholders, and at enhancing the cooperation for NBS co-design and implementation. Most of the approaches described in the scientific literature aiming to eliminate the conflict among different decision-actors, or to reduce it under an acceptable degree, consist in carrying out a consensus reaching process, aimed at obtaining a collective solution as close as possible to unanimous agreement (REF). These approaches assume that conflicts among decision-actors derive from



ambiguity in problem framing and non-conformity in their individual objectives and preferences towards alternatives (Liu et al., 2019). Reducing the distances (differences) between decision-actors preferences may lead to lower level of conflict and higher-quality group decisions (REF, Giordano et al., 2007). The above mentioned approach neglects the relationships among decision-actors and the role of social network in influencing decision-actors' behaviour. They are seen as independent individuals (Liu et al., 2019). Nevertheless, individuals do not make decisions in a vacuum, but social interactions can alter choices and decisions (Kolleck, 2013; Siegel, 2009; Sueur et al., 2012). Evidences demonstrate that the structure of the social networks, both in terms of patterns of connections and the way individuals are distributed across them, affect interdependent behaviour of the agents and the aggregated outcomes of the collective decision process (Siegel, 2009). Moreover, the degree of influence depends on the strength of the relationships between two decision-makers (Liu et al., 2019). Though interaction mechanisms, different decision-actors tend to align their problem frames, overcoming the barriers due to the presence of ambiguity (Brugnach et al., 2011; Dewulf et al., 2009; Dewulf & Bouwen, 2012).

There is a wide support in decision and conflict analysis for distinguishing two categories of conflict, i.e. i) those provoked by existing differences among decision-makers over problem perceptions and preferences; ii) conflicts due to disharmonious relationships among decision-actors (REF). Correlations have been detected between these two kinds of conflict in multi-actors decision-making environment. That is, conflicts may not occur between decision-makers with a rather different problem frames, but with good relationships. Conversely, highly similar opinions cannot ensure the absence of conflicts between decision-makers if they distrust each other (Liu et al., 2019). It has been suggested that divergent frames can still yield organized collective action when the interaction frames are sufficiently aligned (Giordano et al., 2017).

Starting from these premises, the work carried out in NAIAD aimed at demonstrating that effective network of interaction in multi-actors decision-making environment could contribute at reducing the level of conflict due to differences in problem understandings and, consequently, could enable collective actions for NBS design and implementation. Effective social network has the capacity to promote constant exchange and deliberation, enabling ideological or structural changes and generating new knowledge (Kolleck, 2013). Networking Interventions approach has been implemented in this in this work to enhance the existing network of interactions involving the different decision-actors and stakeholders (Valente, 2012). Network Interventions are based on the diffusion of innovations theory, which explains how new ideas and practices spread within and between communities. Network interventions are purposeful efforts using social network characteristics to generate social influence, accelerate behavioural changes, and



enhance organizational performances through punctual interventions in specific nodes of the network, that could act as leverage points in the system (Valente, 2012; REF).

An innovative approach based on the integration between Social Network Analysis (SNA) and Fuzzy Cognitive Map (FCM) was implemented in order to support the design of suitable Networking Interventions. Specifically, SNA had the potential to support the detection of the key nodes in the network for the interventions implementation. FCM-based approach was used for defining the kind of networking intervention to be implemented and for simulating intervention scenarios (Kok, 2009).

SNA has the capacity to support collaborative decision-making processes by dealing with the following issues: i) identification of networks of interactions (existing, missing and realistic cooperation), and investigation of actors, structures and network boundaries; ii) innovation potentials through network development strategies (where and how cooperation can be optimized, and where and how alterations are possible and reasonable); iii) identification of problems of coordination, information and motivation; iv) identification of weakness in the knowledge transfer process (Kolleck, 2013).

The process for mapping the complex network of interactions involving the different actors has been already described in the D3.3. It is worth citing here that the map showing the connections between decision-makers, information and tasks was developed accounting for both individual semi-structured interviews and a stakeholders' workshop. Figure 12 shows the map of Agent X Agent interactions.

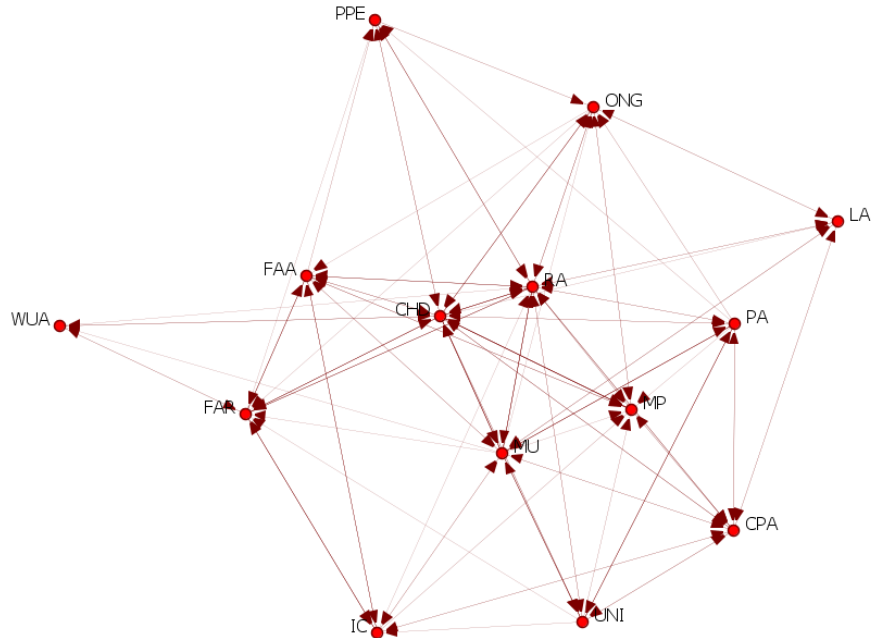


Figure 12: Agent X Agent interaction map.

The obtained maps were, hence, used for detecting the key elements of vulnerability in the network. An element was considered a vulnerability if its failure would lead to a failure – or reduction of effectiveness – of the whole network. In this work we assumed that a key vulnerability in the organization can be due agents, information and tasks.

4.2. Vulnerabilities detection

The following graph theory measures were implemented in the network analysis. 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 10: Graph theory measures for detecting key vulnerabilities in the network of interaction.

Network	Measure	Meaning
Agent X Agent	Centrality degree	
Agent X Knowledge	Most knowledge	An agent with a few and weak connections with the others would be capable to carry out important tasks and share key pieces of knowledge
Agent X Task	Most task	



Agent X Knowledge	Most knowledge	A piece of knowledge with a high centrality degree and high most task degree is key in the process because it enable the access to other pieces of knowledge and allow the fulfillment of several tasks. Nevertheless, a low Most knowledge measure means that it has a low level of access for many agents.
Knowledge X Knowledge	Centrality degree	
Knowledge X Task	Most task	A task with a high centrality degree is needed in order ot enable the fulfillment of the other tasks. A low Most task measure means that this key task is not cooperatively performed. The risk of failure is high, leading to the impairment of the other tasks.
Agent X Task	Most task	
Task X Task	Centrality degree	

As shown in the table 9, different measures were aggregated in order to detect the key vulnerabilities in the network of interactions. Specifically, an agent could be considered as a vulnerable element if she/he has a low centrality degree – that is, weak connections with the other actors – and a high number of tasks to be carried out in the collective process for risk management. In this conditions, the agent would not be able to cooperate with the others and, thus, there is the risk of not fulfilling the tasks. Similarly, an agent with high most knowledge degree has access to a high number of pieces of important knowledge. Nevertheless, a low centrality degree in the Agent X Agent network means that this agent is poorly connected in the network, reducing the effectiveness of the knowledge flow within the network.

A piece of knowledge could represent a vulnerability if it is central in the process – i.e. enable the access to other kinds of knowledge and/or allow the fulfilment of important tasks – and it is not effectively shared within the network. Finally, a task could represent a vulnerability if it carried out by a single agent and if it plays a key role in activating other important tasks. In these conditions, if the exclusive agent would fail in carrying out this task, the whole process will be affected.

Table 11: it shows the vulnerabilities detected in the Medina del Campo demo.

Key vulnerabilities	Type	Meaning in the NBS process
WUA	Agent	This agent is characterized by a quite low centrality degree in the Agent X Agent network. That is, it has few and weak connections with the other actors. It is supposed to carry out important tasks.



Water rights management	Task	This task has a high centrality degree in the Task X Task network. Therefore, it enable the fulfillment of other important tasks. Nevertheless, it is connected exclusively with the CHD.
Technical support for crop selection	Knowledge	This piece of knowldge plays a key role in carrying out the most important tasks (Knowledge X Task network). Nevertheless, it has a low Most knowledge degree in the Agent X Knowledge network and, thus, it is not effectively shared in the network.
GW state	Knowledge	This piece of knowledge has a high centrality degree in the Knowledge X Knowledge network, which means that is enables the access to other important pieces of information. Nevertheless, only few agents have access to it (Agent X Knowledge network).

The results of this analysis allowed to detect the key vulnerabilities in the network that need to be tackled through the design and implementation of the network interventions. As described in the next section, the FCM-based approach was, then, implemented for supporting the design of the interventions.

4.3. Co-designing networking interventions

A second stakeholders workshop was organized in order to co-design the networking interventions capable to overcome the above mentioned vulnerabilities. To support this process a Fuzzy Cognitive Map (FCM) based approach was implemented. Figure 13 shows the model developed referring to the knowledge collected during the stakeholders' interactions.

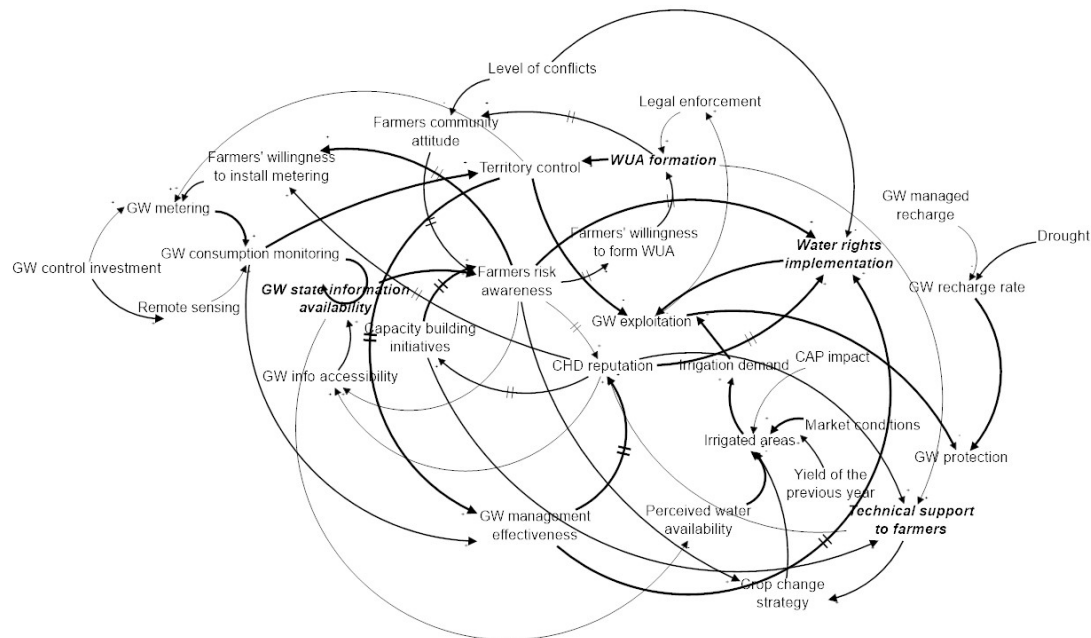


Figure 13: Aggregated FCM describing the causal connections among the different variables influencing the effectiveness of NBS.

The causal connections in the FCM were used to support the phase of network analysis and the definition of the networking interventions. Concerning the first point, FCM were used to identify the main reasons leading to a network vulnerability – e.g. why an actor is isolated in the network? What are the main barriers hampering the effective sharing of an information? To this aim, the causal connections leading to the FCM variable describing the key vulnerabilities were analysed.

FCM were, then, used to analyse how these vulnerabilities may affect the effectiveness of the risk management process - e.g. what could happen if a certain information is not shared? What could be the negative impact on the quality of the risk management process due to the low centrality of a certain decision-actor? To this aim, we referred to the FCM capability to simulate qualitative scenarios.

The first vulnerability detected through the SNA was the WUA. The associated variable in the FCM is “WUA formation process”. As shown in the model, the value of this variable is weakly influenced by the “legal enforcement”, and strongly affected by the “Farmers’ willingness to form WUA”, whose value in turn depends on the “farmers’ risk awareness”. The value of the “WUA formation process” has a strong effect on the variable “territory control”, and consequently, on the “GW exploitation”.



The second key vulnerability in the SNA is the task “Water rights management”. The connected variable in the FCM is the “Water rights implementation”, whose value is strongly affected by the “CHD reputation”, the “Farmers’ risk awareness” and the “GW management effectiveness”. This means that, according to the knowledge elicited during the individual interviews, the water rights would be implemented if farmers would perceive positively the CHD role in the groundwater management, and if farmers would have a positive opinion of the GW management. The effective implementation of the water rights would have led to a reduction of the GW exploitation.

The third key vulnerability in the network of interactions is the technical support to farmers for enabling crop change. The value of this variable in the FCM is weakly affected by the WUA formation process, i.e. the WUA can facilitate the flow of technical information towards the farmers. Moreover, the FCM shows that the effectiveness of the flow of technical information is affected by the CHD reputation. Finally, the availability of the technical support impacts the farmers’ willingness to implement crop changes strategies and, thus, reduce the GW exploitation.

Finally, the fourth key vulnerability in the network of interactions was the “GW state information”. The FCM shows that the value of this variable is affected by the availability and reliability of data on the GW consumption (i.e. GW metering), and by the CD reputation. The availability of GW state information is expected to have an impact on the value of the farmers’ risk awareness and, consequently, the formation of WUA and the implementation of the crop change strategy.

The results of this analysis were used for supporting the definition of the networking interventions, that is, those interventions whose main scope is to enhance the effectiveness of the interaction mechanisms and, in doing so, overcome the barriers to NBS implementation. To this aim, a second stakeholders’ workshop was organized in the case study, involving institutional actors, farmers, representatives of farmers’ association and local citizens.



Figure 14: Stakeholders' workshop for the definition of the networking interventions.

At the beginning of the workshops, participants agreed to merge two of the defined vulnerabilities, i.e. the WUA formation and the management of water rights. According to participants' opinion, the connection between these elements were considered too tight to allow a separate discussion. Therefore, participants were divided into 3 small groups, composed by maximum 10 stakeholders. Each group focused on one of the identified vulnerabilities. Starting from the results of the SNA and FCM analysis, participants were requested to identify Actors, Tasks and Information that need to be introduced in the network in order to overcome the defined vulnerabilities. Table 11 shows the results of the stakeholders' discussion in the four groups.

Table 12: Intervention mentioned by the stakeholders during the workshop.

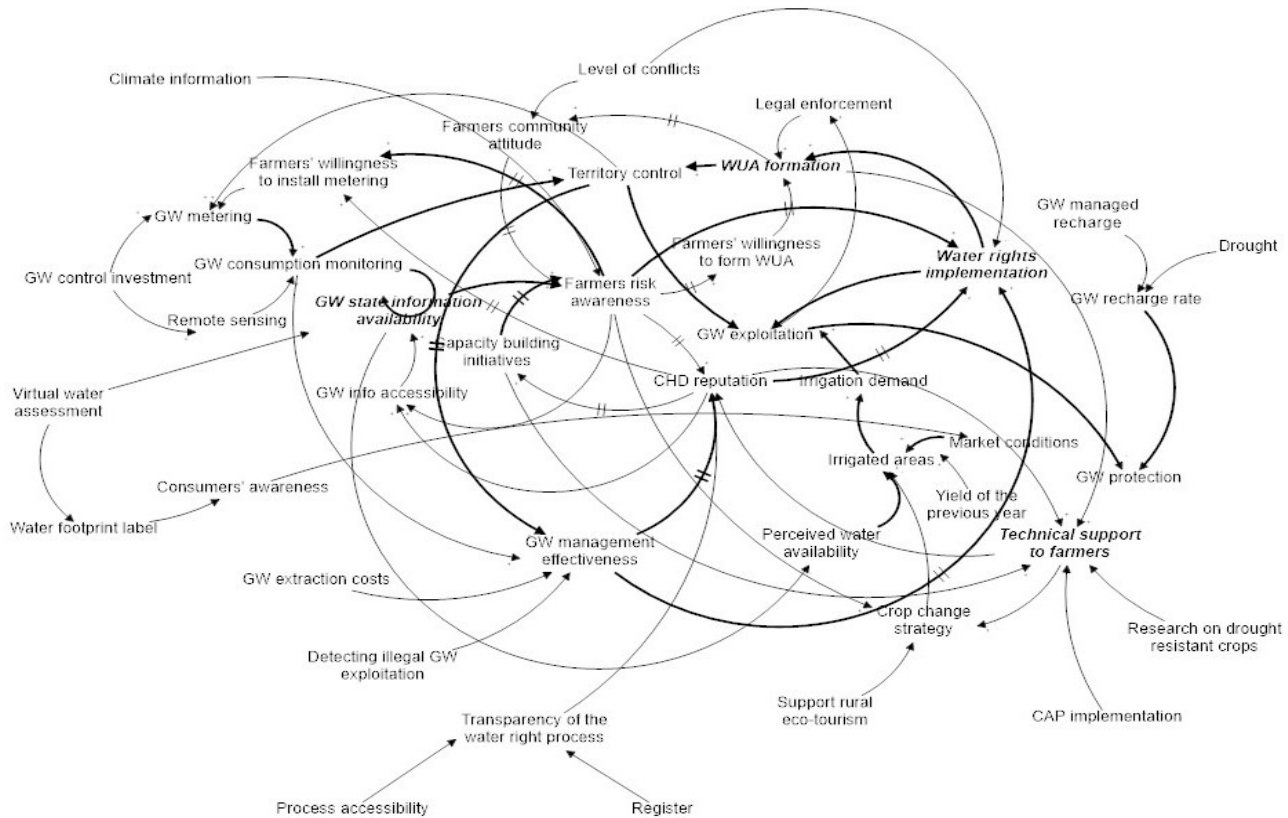
Vulnerability	Actors	Knowledge	Tasks
WUA formation and water rights management	Municipalities	Information on the water right assignment process	Detect illegal GW exploitation
	Regional Authority		Voting system in the CHD
	Ministry		Enhance transparency of the process
			Create a register of the rights
GW state information	Ministry of environmental	Climate information	Sustain rural eco-tourism



Technical support to farmers for crop changes	CHD	Water footprint label for the products	Consumers awareness raising
	Famers	GW extraction costs	Implementing drought management plan
		Virtual water	GW metering
	Technicians	Crop water requirements	Enhance CAP distribution
	Regional Authority	Information drought resistant crops	Training on novel crops
	Universities and research centres	Market evaluation	Crop-based water allocation
	Farmers organization		Awareness raising on sustainable agriculture

The interventions suggested by the stakeholders were integrated in the FCM in order to simulate intervention scenarios, and, thus, assess their effectiveness in facilitating the NBS implementation. The interventions suggested by stakeholders were translated into FCM variables and connected to the main vulnerabilities, either directly or through other elements in the FCM.

Figure 15 shows the FCM with the interventions selected during the stakeholders' workshop.



The FCM was, then, used for simulating intervention scenarios. Three different intervention scenarios were developed accounting for the three main vulnerabilities: i) WUA formation and water rights implementation; ii) GW state information; and iii) Technical support for crop changes.

Figure 16 shows the comparison among the three scenarios for what concerns the impacts of the selected interventions on the NBS effectiveness. The scenarios were compared accounting for the value of the variable “GW protection”.

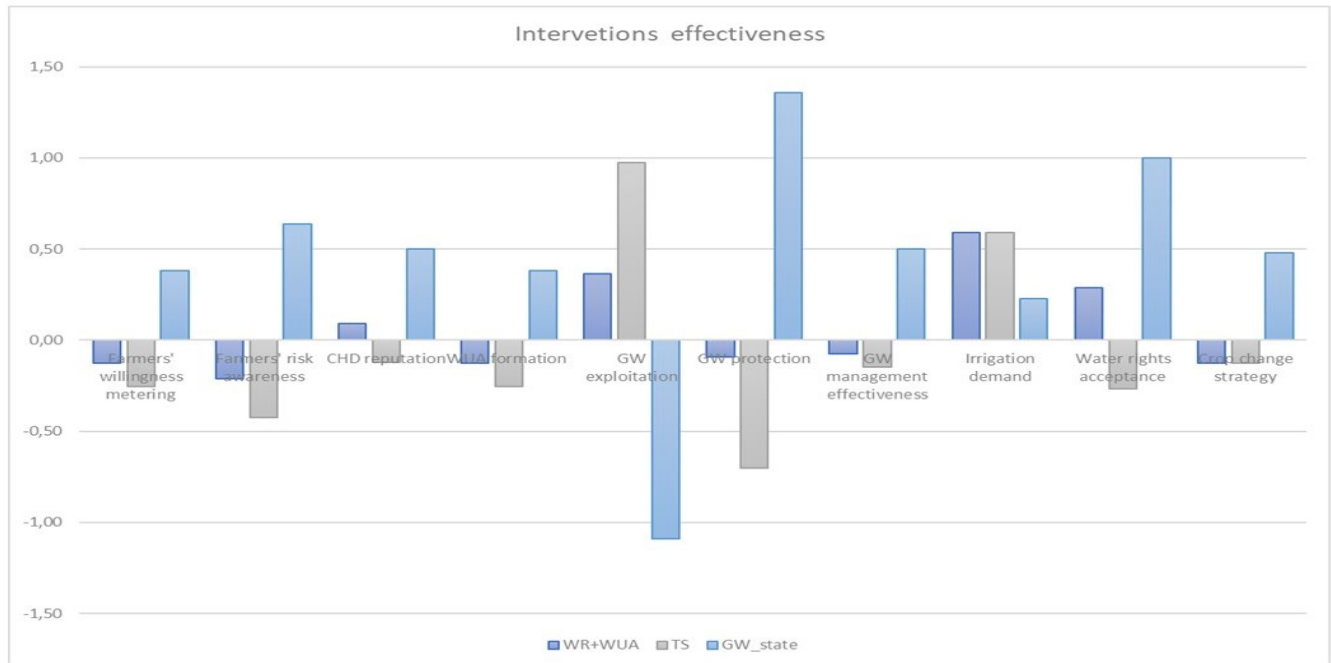


Figure 16: Comparison among the three intervention scenarios.

Figure 16 shows that the most effective networking interventions are those aiming at enhancing the availability, reliability and accessibility of the information related to the GW state. The FCM model demonstrates that these interventions could have a twofold positive impact. On the one hand, they could lead to an increase of the farmers' risk awareness and, in doing so, they could contribute in enabling the shift towards less water-demanding crops. On the other hands, the availability of reliable information on the GW state could allow the CHD to enhance the effectiveness of the territory control and the GW management. This, in turn, could have a positive impact on the farmers' perception of the CHD role and, consequently, could lead to a higher acceptance of the water rights management process.

5. DISCUSSION AND CONCLUDING REMARKS

This document aimed at summarizing the activities carried out by WP3 in the different NAIAD demos, and to draw conclusions related to the effectiveness of the implemented methods and approaches in affecting the stakeholders' risk perception and NBS acceptance. Based on the lessons learned during WP3 activities in different NAIAD demos, this section provides key recommendation for enhancing NBS social acceptance. In order to facilitate the readability of



this section, we grouped the lessons learned according to the three main steps in the implemented work, i.e. i) stakeholders' engagement in NBS co-design; ii) trade-offs analysis and conflicts detection; iii) networking intervention for NBS co-design and implementation.

5.1. Stakeholders engagement process: the role of participatory and integrated models.

Among the different methodologies for facilitating the stakeholders' engagement in risk management process, a participatory modelling approach has been implemented in this work. The experiences carried out in NAIAD demonstrated the importance of making explicit to the stakeholders how the knowledge they provided during the different phases was actually used for developing the model. This contributed to create a sense of ownership toward the developed model, facilitating the interaction with the stakeholders and enhancing the thrust and the legitimacy of the developed model and of the process for NBS design. The work carried out in NAIAD mainly aimed at enhancing the potential richness, diversity and complexity of the collected knowledge, rather than searching consensus among participants. Therefore, the modelling exercises started collecting and structuring individual contributions. Moreover, even if we aggregated the individual inputs for developing either the aggregated FCM or the SDM, we analyzed and kept track of the differences among the different stakeholders' problem understanding.

Using a model based on the stakeholders' knowledge had pros and cons. Concerning the latter, we need to say that using such a model for supporting the interactions with decision-makers – mostly technicians used to base their decisions on physically-based models – was not always easy. Quantitative assessments were often considered more reliable than the results of a semi-quantitative model, as the one developed in WP3. Therefore, supplementary efforts were required by WP3 partners in order to clarify the structure and the scope of the developed model.

Nevertheless, the selected modelling approaches allowed to shed a light on the complex cause-effects chain affecting the system behavior and NBS effectiveness. By contributing to the model development, stakeholders became aware of this complexity and realized that NBS effectiveness is influenced by several elements, ranging from the physical to the socio-institutional ones. As result of this learning process, stakeholders and decision-makers selected several socio-institutional actions to be implemented as “supportive” measures for NBS effectiveness. They became aware that infrastructures – either green or grey – require changes in the socio-institutional system in order to pursue their goals. In this direction, the scenario analysis is a key tool to perform a comparative analysis of the impacts of different strategies, and to describe the benefits and co-benefits produced. Although the scenario analysis is semi-quantitative, and there might be limitations in the capability to describe how specific strategies mutually interact, the process itself represents a step forward in supporting active engagement, knowledge sharing



and co-design across several stakeholders and experts, from high-level decision-makers to communities and local organizations.

Moreover, the participatory approaches for developing the integrated models contributed to make participants aware of the wide web of impacts due to NBS implementation. Participatory and integrated tools, such as SDM and FCM, helped overcoming one of the key limits of the existing frameworks for NBS assessment, that is the lack of structured representations of their multi-dimensionality. Co-benefits were considered in many cases even more important than the reduction of the water-related risks, and were used as the main elements for the co-design of the NBS.

Lastly, the NAIAD Demos demonstrated the relevance of using participatory tools to increase social acceptance towards NBS, since the whole process helped breaking down some of the existing socio-institutional barriers, mainly related to the limited knowledge and to the partial involvement of the stakeholders in the discussion. The active participation of stakeholders throughout the process of NBS design is crucial in order to move beyond individual perception and problem understanding, and to support building a shared view of the problem under consideration. Additionally, defining a shared problem frame and group model facilitates interdisciplinary and cross-sectoral communication and collaboration. Given the multiplicity of risk-management goals and impacts, the active participation of stakeholders in the process of identification of benefits and co-benefits, along with the definition of connections between such elements and the NBS, is of utmost importance in raising awareness about NBS effectiveness. This was highlighted also by the increasing interest and participation in project activities. The involvement of both institutional actors (policy- and decision-makers) and communities/organizations represented a relevant opportunity for including knowledge and creating a richer picture.

Concerning the potential replicability of the adopted approach, the framework implemented in NAIAD is flexible enough to be adapted to different sites and conditions. In fact, it was developed and used, within the NAIAD project, in two rather different DEMOs, i.e. the Glinscica river (small scale river basin, urban area, affected mainly by flooding issues) and in the Lower Danube (large scale basin, mostly rural, affected by both floods and droughts), with positive results. More in general, all tools and methods included in the framework have several applications in environmental issues, showing several advantages and potentialities that may contribute to the effort of overcoming the main barriers to NBS implementation.



Additionally, the whole framework could be either fully or partially implemented, according to the specific needs. Therefore, the ‘divergent’ and the ‘convergent’ thinking phases can be even carried out separately, in case the focus is more on the analysis of ambiguities and differences in problem perception or on the definition of a shared view of the system. Furthermore, qualitative (such as e.g. FCMs and CLDs) or quantitative SDM tools (e.g. Stock and flow models) can be used according to the availability and quality of input data, and to the expected quality of results. One general remark that should be considered is that in general SDM tools could support decision-making at a strategic, system-wide level, while there is a limited applicability in the analysis of individual or micro-behaviors. However, the potential of SDM as a meta-model, capable to aggregate other different tools and models, should be carefully explored. In fact, the inclusion of more specific information (e.g. from hydrological or economic models) could significantly improve the quality of model results, and therefore their applicability for decision support.

5.2. Trade-offs analysis for reducing conflict risk

Two key messages can be identified from the work carried out in the NAIAD demos. Firstly, the analysis of the obtained results, as described in section 3, confirmed the hypothesis at the basis of this work, that is: i) ambiguity in defining and valuing the co-benefits produced through the NBS implementation could lead to trade-offs among different stakeholders, as already discussed by (Small et al., 2017; Wam et al., 2016; Clark et al., 2018); ii) the analysis of trade-offs cannot ignore the dynamic evolution of the system due to the implementation of the NBS. Therefore, the trade-offs analysis requires methods and tools capable to handle the diversity in problem frames among the different stakeholders, and suitable to simulate the dynamic evolution of complex systems. The implemented approach allowed us to overcome the main limits of the indicators-based approaches (e.g. Calliari, et al., 2019; Kabisch et al., 2016; Raymond et al., 2017), which are mainly static.

Secondly, we learned that, in order to make NBS effective in reducing climate-related risks and producing the expected co-benefits, soft-institutional measures need to be implemented as complementary actions, as already described in the previous section. Nevertheless, some of these measures could provoke trade-offs among the stakeholders. As shown in the Lower Danube demo, on the one hand, the implementation of the “territory control” facilitates the creation of natural protected areas, because it facilitates the implementation of spatial planning rules, among which the establishment of protected areas by the central government. Hence, it enhances the biodiversity in the study area. On the other hand, this action could have a negative



impact on the “community risk awareness”, which was one of the co-benefits selected by some stakeholders. This was mainly because, as learned during the stakeholders’ knowledge elicitation phase, a deep involvement of institutional actors in controlling the territory may reduce the capability/willingness of local communities of being responsible for their own environment. Therefore, the analysis of the trade-offs due to the NBS implementation claims for a clear understanding and modelling of the complex cause-effects chains affecting the NBS impacts on the system. Moreover, the socio-institutional actions – i.e. the complementary actions – should be accounted for in the trade-off analysis.

The results of the trade-offs analysis can be used by decision-makers for enhancing the interaction with the stakeholders, in order to avoid conflicts and enhance NBS acceptance. The described example shows the importance of raising stakeholders’ awareness about the great potentialities of the NBS implementation in creating new community development opportunities due to the eco-tourism. Therefore, the communication should emphasize the production of the co-benefits, rather than being simply focused on the reduction of the climate-related risks.

Moreover, the developed methodology for the trade-offs analysis demonstrated its suitability to support decision-makers in selecting the most suitable NBS accounting for the potential conflicts among different stakeholders. The early detection and analysis of trade-offs due to the production of co-benefits could contribute to select the NBS capable to keep at a low level the level of conflicts among stakeholders and, thus, facilitate its implementation. Finally, the trade-offs analysis allows to identify the stakeholders that need to be addressed in order to enhance to social acceptance of NBS. In the proposed example, interacting with the stakeholders that assigned a high value to agricultural productivity is key for reducing the risk of conflicts over NBS implementation.

5.3. Networking interventions for enhancing NBS co-design and implementation

The experiences carried out in the NAIAD demos demonstrated that among the different barriers that could hamper the NBS design and implementation, the lack of effective interaction mechanisms among the different actors involved/interested in the process could play a key role.

The design and implementation of a NBS does not happen in a vacuum. The way the decision-actors and stakeholders interact each other, exchange information and share tasks could strongly affect the effectiveness of the collaborative process at the base of NBS design. In NAIAD, efforts were carried out in order to unravel the complex network of interactions taking place at the demo level – most of the activities related to this issue were carried out in the Medina del



Campo demo – and to detect the key elements of vulnerability. A modelling approach based on Social Network Analysis was implemented.

Networking interventions were co-defined in a stakeholders' workshop. Those interventions are punctual interventions, implemented in specific nodes of the network of interactions, that could act as leverage points in the system, accelerate behavioural changes, and enhance organizational performances. The selected interventions were meant to enhance the flow of key information among the different decision-makers and stakeholders, to eliminate or reduce barriers to collaboration, to bring in the process key actors, i.e. the actors that can speed up the process of innovation diffusion.

The stakeholders-driven activities carried out in Medina del Campo showed the effectiveness of the networking interventions. We learned that stakeholders' behaviour may represent a strong barrier to the implementation of the NBS. E.g. implementing Managed Aquifer Recharge actions may not be sufficient to preserve groundwater quality if farmers would continue to exploit groundwater for irrigation purposes at the actual rate. Behavioural changes are required. The experiences carried out in NAIAD showed that acting on information and/or enhancing the role of key actors could have a positive impact on the NBS co-design and implementation process.

5.4. Future developments

The previous sections describe the lessons we learned during the NAIAD implementation and how these results can be used for enhancing the NBS design and implementation. Nevertheless, there are still quite few issues that remained unaddressed related to the use of stakeholders' knowledge and perception in NBS design. This section aims at describing the needs for future research in this domain.

The first issue that need to be addressed concerns the actual usability of integrated model in specific decision-making domain, such as those related to investments and insurance policy. As discussed in the previous sections, involving stakeholders in modelling the systems to be managed, the risk to be addressed and the NBS effectiveness enable learning processes concerning the NBS role and the need for accounting for the synergies between different NBSs, and between NBS and the socio-institutional actions. Nevertheless, the qualitative or semi-quantitative nature of the participatory models represented a barrier hampering the usability of these models for enabling the debate with those decision-makers that are familiar with quantitative models, and had a limited willingness to accept no-numerical results. On the one hand, we need to fill the gaps between the information that can provided using participatory and integrated models and the decision-makers' information needs. On the other hand, efforts are needed to make these decision-makers aware that NBS implementation is more than a reduction of damages. This process started in NAIAD, but must be continued.



The second issue that still need to be addressed concerns the scale of NBS implementation. NAIAD clearly demonstrated that, in order to be effective, NBSs must be considered as a “system” of solutions. Nevertheless, most of the modelling tools for assessing the NBS effectiveness in reducing water-related risks – i.e. physical models for risk assessment – seems to be inadequate for analysing the synergies among the different actions. This, in turn, negatively affects the possibility to integrate physically-based model for risk analysis in participatory-integrated models.

REFERENCES

- Ackermann, C., & Alexander, J. (2016). Researching complex projects: Using causal mapping to take a systems perspective. *International Journal of Project Management*, 34, 891–901.
- Ackermann, F., Howick, S., Quigley, J., Walls, L., & Houghton, T. (2014). Systemic risk elicitation: Using causal maps to engage stakeholders and build a comprehensive view of risks. *European Journal of Operational Research*, 238, 290–299.
- Alves, A., Gersonius, B., Kapelan, Z., Vojinovic, Z., & Sanchez, A. (2019). Assessing the Co-Benefits of green-blue-grey infrastructure for sustainable urban flood risk management. *Journal of Environmental Management*, 239(December 2018), 244–254. <https://doi.org/10.1016/j.jenvman.2019.03.036>
- Ananda, J., & Herath, G. (2003). Incorporating stakeholder values into regional forest planning: a value function approach. *Ecological Economics*, 45(1), 75–90. [http://doi.org/10.1016/S0921-8009\(03\)00004-1](http://doi.org/10.1016/S0921-8009(03)00004-1)
- Bain, P. G., Milfont, T. L., Kashima, Y., Bilewicz, M., Doron, G., Garðarsdóttir, R. B., ... Johansson, L. (2016). Co-benefits of addressing climate change can motivate action around the world. *Nature Climate Change*, 6(September 2015). <https://doi.org/10.1038/NCLIMATE2814>
- Belton, V., Ackermann, F., and Shepherd, I. (1997). Integrated support from problem structuring through to alternative evaluation using COPE and VISA. *Journal of Multi-Criteria Decision Analysis*, 6:115-130.
- Brugnach, M., Dewulf, A., Henriksen, H. J., & van der Keur, P. (2011). More is not always better: coping with ambiguity in natural resources management. *Journal of Environmental Management*, 92(1), 78–84. <https://doi.org/10.1016/j.jenvman.2010.08.029>
- Calliari, E., Staccione, A., & Mysiak, J. (2019). Science of the Total Environment An assessment framework for climate-proof nature-based solutions. *Science of the Total Environment*, 656, 691–700. <https://doi.org/10.1016/j.scitotenv.2018.11.341>



- Dewulf, A., & Bouwen, R. (2012). Issue Framing in Conversations for Change. *The Journal of Applied Behavioral Science*, 48(2), 168–193. <https://doi.org/10.1177/0021886312438858>
- Eden, C. (1988). Cognitive mapping: a review. *European Journal of Operational Research*, 36:1-13
- Eden, C. and Ackermann, F. (2004). Cognitive mapping expert views for policy analysis in the public sector. *European Journal of Operational Research*, 152:615-630.
- European Environment Agency (EEA), (2018). Economic losses from climate-related extremes. <https://www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-3/assessment-1>. [Accessed: 18 July 2018]
- Frantzeskaki, N. (2019). Seven lessons for planning nature-based solutions in cities. *Environmental Science and Policy*, 93(December 2018), 101–111. <https://doi.org/10.1016/j.envsci.2018.12.033>.
- Giordano, R., Brugnach, M., & Pluchinotta, I. (2017). Ambiguity in Problem Framing as a Barrier to Collective Actions: Some Hints from Groundwater Protection Policy in the Apulia Region. *Group Decision and Negotiation*, 26(5). <https://doi.org/10.1007/s10726-016-9519-1>
- Global Facility for Disaster Reduction and Recovery, GFDRR. (2013). Annual Report, 2013 https://www.gfdrr.org/sites/gfdrr/files/publication/GFDRR_AR_FY13.pdf [Accessed: 30 June 2018]
- Howe, C., Suich, H., Vira, B., & Mace, G. M. (2014). Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world. *Global Environmental Change*, 28(1), 263–275. <https://doi.org/10.1016/j.gloenvcha.2014.07.005>
- Jacobs, S., Dendoncker, N., Martín-lópez, B., Nicholas, D., Gomez-baggethun, E., Boeraeve, F., ... Washbourne, C. (2016). A new valuation school : Integrating diverse values of nature in resource and land use decisions. *Ecosystem Services*, 22(November), 213–220. <https://doi.org/10.1016/j.ecoser.2016.11.007>
- Jasanoff, S. (2007). Technologies of humility. *Nature*, 450(7166), 33. <https://doi.org/10.1038/450033a>
- Jetter, A. J., & Kok, K. (2014). Fuzzy Cognitive Maps for futures studies—A methodological assessment of concepts and methods. *Futures*, 61, 45–57. <https://doi.org/10.1016/j.futures.2014.05.002>



- Jeworrek, T. (2018). Natural disasters in 2017 were a sign of things to come – New coverage concepts are needed, Munich Re, 2018 <https://www.munichre.com/topics-online/en/2018/topics-geo/2017-was-a-wake-up-call>. [Accessed: 11 July 2018]
- Josephs, L. I., & Humphries, A. T. (2018). Identifying social factors that undermine support for nature-based coastal management. *Journal of Environmental Management*, 212, 32–38. <https://doi.org/10.1016/j.jenvman.2018.01.085>
- Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., ... Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and Society*, 21(2), art39. <https://doi.org/10.5751/ES-08373-210239>
- Keeney, R.L. (1992). *Value Focused Thinking: A Path to Creative Decisionmaking*. MA: Harvard University Press.
- Keeney, R.L. and Raiffa, H. (1976). *Decision with Multiple Objectives: Preferences and Value Trade-offs*. Wiley, New York.
- Kok, K. (2009). The potential of Fuzzy Cognitive Maps for semi-quantitative scenario development, with an example from Brazil. *Global Environmental Change*, 19(1), 122–133. <https://doi.org/10.1016/j.gloenvcha.2008.08.003>
- Kolleck, N. (2013). Social network analysis in innovation research: using a mixed methods approach to analyze social innovations. *European Journal of Futures Research*, 1(1), 1–9. <https://doi.org/10.1007/s40309-013-0025-2>
- Liu, B., Zhou, Q., Ding, R. X., Palomares, I., & Herrera, F. (2019). Large-scale group decision making model based on social network analysis: Trust relationship-based conflict detection and elimination. *European Journal of Operational Research*, 275(2), 737–754. <https://doi.org/10.1016/j.ejor.2018.11.075>
- Mingers, J., Rosenhead, J. (2004). Problem structuring methods in action. *European Journal of Operational Research* 152, 530–544.
- O'Donnell, E. C., Lamond, J. E., & Thorne, C. R. (2017). Recognising barriers to implementation of Blue-Green Infrastructure: a Newcastle case study. *Urban Water Journal*, 14(9), 964–971. <https://doi.org/10.1080/1573062X.2017.1279190>
- Özesmi, U., & Özesmi, S. L. (2004). Ecological models based on people's knowledge: A multi-step fuzzy cognitive mapping approach. *Ecological Modelling*. <https://doi.org/10.1016/j.ecolmodel.2003.10.027>



- Pagano, A., Pluchinotta, I., Pengal, P., Cokan, B., & Giordano, R. (2019). Engaging stakeholders in the assessment of NBS effectiveness in flood risk reduction: A participatory System Dynamics Model for benefits and co-benefits evaluation. *Science of the Total Environment*, 690, 543–555. <https://doi.org/10.1016/j.scitotenv.2019.07.059>
- Pluchinotta I., Esposito D., Camarda D. (2019). Fuzzy cognitive mapping to support multi-agent decisions in development of urban policy-making. *Sustainable Cities and Society*, April 2019, Volume 46, <https://doi.org/10.1016/j.scs.2018.12.030>
- Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Razvan, M., ... Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environmental Science and Policy*, 77(July), 15–24. <https://doi.org/10.1016/j.envsci.2017.07.008>
- Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., ... Stringer, L. C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management*, 90(5), 1933–1949. <http://doi.org/10.1016/j.jenvman.2009.01.001>
- Reed, M. S., Kenter, J., Bonn, A., Broad, K., Burt, T. P., Fazey, I. R., ... Ravera, F. (2013). Participatory scenario development for environmental management: A methodological framework illustrated with experience from the UK uplands. *Journal of Environmental Management*, 128, 345–362. <https://doi.org/10.1016/j.jenvman.2013.05.016>
- Sanon, S., Hein, T., Douven, W., & Winkler, P. (2012). Quantifying ecosystem service trade-offs: The case of an urban floodplain in Vienna, Austria. *Journal of Environmental Management*, 111, 159–172. <https://doi.org/10.1016/j.jenvman.2012.06.008>
- Santoro, S., Pluchinotta, I., Pagano, A., Pengal, P., Cokan, B., & Giordano, R. (2019). Assessing stakeholders' risk perception to promote Nature Based Solutions as flood protection strategies: The case of the Glinščica river (Slovenia). *Science of the Total Environment*, 655, 188–201. <https://doi.org/10.1016/j.scitotenv.2018.11.116>
- Sepehri, A., & Sarrafzadeh, M.-H. (2019). Activity enhancement of ammonia-oxidizing bacteria and nitrite-oxidizing bacteria in activated sludge process: metabolite reduction and CO₂ mitigation intensification process. *Applied Water Science*, 9(5), 1–12. <https://doi.org/10.1007/s13201-019-1017-6>
- Shrestha, S., & Dhakal, S. (2019). An assessment of potential synergies and trade-offs between climate mitigation and adaptation policies of Nepal. *Journal of Environmental Management*, 235(January), 535–545. <https://doi.org/10.1016/j.jenvman.2019.01.035>



- Siegel, D. A. (2009). Social networks and collective action. *American Journal of Political Science*, 53(1), 122–138. <https://doi.org/10.1111/j.1540-5907.2008.00361.x>
- Simon, H.A (1956). Rational choice and the structure of the environment. *Psychological Review*, 63(2):129-152.
- Small, N., Munday, M., & Durance, I. (2017). The challenge of valuing ecosystem services that have no material benefits. *Global Environmental Change*, 44, 57–67. <https://doi.org/10.1016/j.gloenvcha.2017.03.005>
- Sueur, C., Deneubourg, J. L., & Petit, O. (2012). From social network (centralized vs. decentralized) to collective decision-making (unshared vs. shared consensus). *PLoS ONE*, 7(2). <https://doi.org/10.1371/journal.pone.0032566>
- Vennix, J. a. M., Akkermans, H. a., & Rouwette, E. a. J. a. (1996). Group model-building to facilitate organizational change: an exploratory study. *System Dynamics Review*, 12(1), 39–58. [https://doi.org/10.1002/\(SICI\)1099-1727\(199621\)12:1<39::AID-SDR94>3.0.CO;2-K](https://doi.org/10.1002/(SICI)1099-1727(199621)12:1<39::AID-SDR94>3.0.CO;2-K)
- Wam, H. K., Bunnefeld, N., Clarke, N., & Hofstad, O. (2016). Conflicting interests of ecosystem services: Multi-criteria modelling and indirect evaluation of trade-offs between monetary and non-monetary measures. *Ecosystem Services*, 22(October), 280–288. <https://doi.org/10.1016/j.ecoser.2016.10.003>
- Wihlborg, M., Sörensen, J., & Alkan Olsson, J. (2019). Assessment of barriers and drivers for implementation of blue-green solutions in Swedish municipalities. *Journal of Environmental Management*, 233(November 2018), 706–718. <https://doi.org/10.1016/j.jenvman.2018.12.018>
- Xing, Y., Jones, P., Donnison, I., 2017. Characterisation of Nature-based Solutions for the Built Environment. Sustainability. p. 9.