Network Analysis, Creative System Modelling and Decision Support: *The NetSyMoD Approach*

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Summary

This paper presents the NetSyMoD approach – where NetSyMod stands for Network Analysis – Creative System Modelling – Decision Support. It represents the outcome of several years of research at FEEM in the field of natural resources management, environmental evaluation and decision-making, within the Natural Resources Management Research Programme. NetSyMoD is a flexible and comprehensive methodological framework, which uses a suite of support tools, aimed at facilitating the involvement of stakeholders or experts in decision-making processes. The main phases envisaged for the process are: (i) the identification of relevant actors, (ii) the analysis of social networks, (iii) the creative system modelling and modelling of the reality being considered (i.e. the local socio-economic and environmental system), and (iv) the analysis of alternative options available for the management of the specific case (e.g. alternative projects, plans, strategies). The strategies for participation are necessarily context-dependent, and thus not all the NetSyMod phases may be needed in every application. Furthermore, the practical solutions for their implementation may significantly differ from one case to another, depending not only on the context, but also on the available resources (human and financial). The various applications of NetSyMoD have nonetheless in common the same approach for problem analysis and communication within a group of actors, based upon the use of creative thinking techniques, the formalisation of human-environment relationships through the DPSIR framework, and the use of multi-criteria analysis through the *m*DSS software.

Keywords: Social Network, Integrated Analysis, Participatory Modelling, Decision Support

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1 NetSyMoD: main aims and features

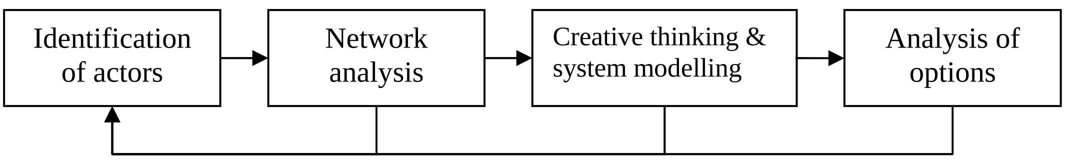
NetSyMoD stands for Network Analysis – Creative System Modelling – Decision Support. The NetSyMoD methodology represents the result of several years of research at FEEM in the fields of resource management, environmental evaluation, and decision-making within the Natural Resources Management Research Programme.

NetSyMoD presents a flexible but rigorous and comprehensive methodological framework, which uses a suite of tools aimed at facilitating the involvement of actors (stakeholders and/or experts) in **decision-making processes (DMPs)**. In these contexts, decision is intended in a broad sense, to include any process in which a choice has to be made by examining the information available on the given issue. The problem itself, the information, and the choice set are defined with the contribution of different actors, who may be various experts in the disciplines relevant for the solution of a certain problem, or the stakeholders and the decision makers that are formally or informally involved in the participatory process of decision-making, for instance during the definition of a local development plan.

It is clearly not the ambition of the NetSyMoD proposal to provide a single methodological approach for each and every possible application context, given the variety of situations in which public participation may be required. Our interest is instead in proposing a general but rigorous framework, which can be adapted to a diverse range of applications, and for which concrete and specific approaches should be identified and tailored. The emphasis is on integrating and implementing within the same framework different state-of-the-art approaches in the field of modelling: from the more traditional use of simulation models in the decision process through the development of ad hoc decision support systems, to the more innovative creative thinking approaches for participative modelling design.

The main components of NetSyMod, which should be common to all of its applications, are reported in the figure below, which represents also the sequence of phases with their connective feedback loops. A "task force group" composed of people with a particular interest in the process and its outcomes, and with a suitable mix of expertise for the various components of NetSyMod, should implement the methodological framework, and specify the most appropriate methodologies to be used.

Figure 1: The four main phases of NetSyMod



In the first two phases the – iterative – identification of actors to be involved in the process (stakeholders and/or experts) takes place, and their reciprocal relationships within social networks are explored and assessed. Once a sort of community of interested parties has been identified, mental modelling and techniques in the field of cognitive mapping are applied by the task force group, with the aim of producing a shared model (that is, a simplified representation of the part of the reality of interest). This model is a formal, albeit simplified, description of the system in question and its causal links, to which the problem pertains and that can be commonly understood and recognised by the actors involved. The systems of interest are those in which human activities interact with each other and with the natural resources.

The main rationale of NetSyMoD is that creative system modelling can provide not only a common ground for the mutual understanding among the parties involved, but also a scientifically sound basis for the development of effective **decision support systems (DSSs)**. The latter may in turn be based upon complex mathematical models, which may find in the methodology proposed an interface for easier communication with the interested public. Or they may well build on less formalised models, based on stakeholders' cognitive maps.

The final phase of decision support may be of a different nature, varying from cases in which group decision-making techniques are applied for supporting choices among a given set of alternative options, to others in which experts have to find a shared ground in the debate about a specific problem.

NetSyMoD can be successfully implemented in the management of natural resources, where it can provide useful input for the structured implementation of participatory planning and management. Two main categories of applications can be distinguished – which are however not mutually exclusive, but may also be encountered together in the same application: (i) the involvement of experts in a decision process or an evaluation exercise, where the environmental problem requires diversified but integrated fields of expertise, and (ii) the involvement of interested actors in a generic participatory process dealing with the management of environmental resources. For example, NetSyMod could be successfully used in:

- participatory planning and decision-making processes for Integrated Water Resource Management;
- transboundary management and negotiation;
- contribution of experts to the formalisation of a shared knowledge base and of integrated models.

NetSyMoD can contribute to the adoption of improved Decision Support System (DSS) tools in decision/policy-making processes related to environmental matters. In fact, building a decision support system tool in a participatory way improves the performance of the tool, increases its acceptability – and, ultimately, the acceptability of the decisions taken with its support. The process of participatory model-building itself may bring about substantial benefits and improvements for natural resource management, in terms of increased knowledge and awareness, reduction of conflicts, and easier implementation of the selected management strategies.

The process of participatory modelling – as much as participatory planning – does however have many pitfalls, which may not only frustrate the efforts of participatory decision-making, but may also, in some cases, lead to counterproductive results. This is the case if, for instance, key stakeholders are not consulted, and/or power relations are not managed in an appropriate way, during the problem conceptualisation phase – arguably the key step in building a DSS is a participatory way.

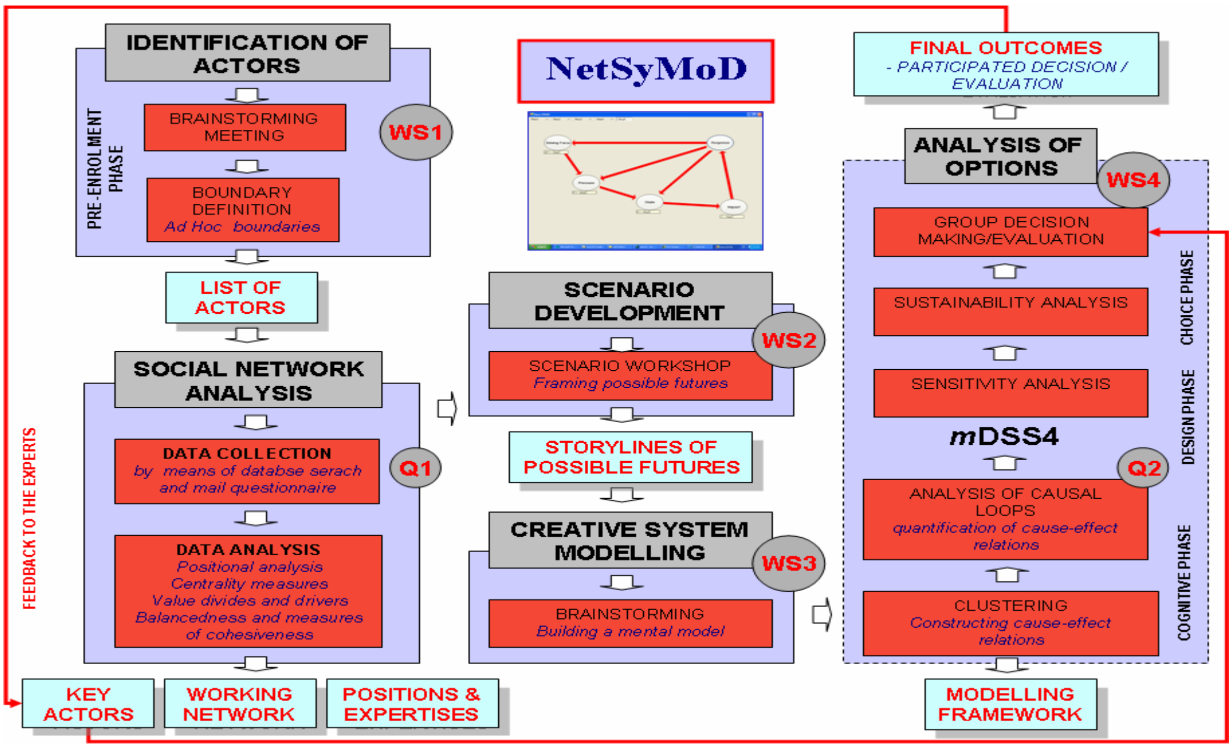
The remainder of the paper will describe in more details the general framework of NetSyMod, and its specific features in the two application categories, following the four phases presented in Figure 1:

- **Actors Identification** (AI), described in Section 3;
- **Social Network Analysis** (SNA), whose main steps are discussed in Section 4;
- **Creative Thinking and System Modelling** (CSM), detailed in Section 5; and

- **Analysis of Options** (AoO), including the use of specific computer tools, which concludes the application of NetSyMoD, and is presented in Section 6.

Prior to entering into the details of the NetSyMod methodological framework, a short digression on the importance of public participation for the management of natural resources will set the problem into context (Section 1).

Figure 2: A graphical scheme of the NetSyMoD approach.



2 Public participation

The "voice of the people" has always been important in the decision-making process in a democratic society. Representative democracy bases itself on traditional ways for gaining citizens' consensus – such as elections and accompanying campaigns. However, these instruments only allow people to choose between different versions of broad policies promoted by the various parties. Elections do not allow citizens to influence day-to-day decision-making and the specific strategies to implement broad government policies. Nowadays, the importance to strengthen these relations between governments and citizens and to implement participatory mechanisms is becoming increasingly evident, particularly with reference to environmental matters[1]. Deliberative democracy is thus gaining consensus, where public participation is seen as stemming from a higher, more general need of democracy, required for legitimate lawmaking (Renn,).

During the Conference on the Human Environment, held in Stockholm in 1972, the "right of environment" was formulated for the first time. This right means that everybody has the right to the protection of his or her environment. One of the major outcomes of the Stockholm Conference was

[1] However, it is of utmost important to precisely distinguish democracy and participation. According to Mohiddin Mohiddin, A., 1998, Partnership: a New Buzz-word or Realistic Relationship? Journal of the Society for International Development 41, pp 5-12. , "democracy entitles people to choose leaders with broad policies most acceptable to them whereas participation in public affairs enables the people to influence the details of policy-legislation, and to continuously monitor their implementation".

an increased awareness and understanding of the fragility of the environment. Thanks to the Conference, the concern for the environment was firmly placed in the international political agenda, even though too little was done to give practical effect to the integration of the environmental issues in economic policy and decision-making. Twenty years after the Stockholm Conference, another United Nations Conference on Environment and Development was organised at Rio de Janeiro. On this occasion, great attention was placed on the need to promote human development by means of an economic growth based on a sustainable management of natural resources. The concept of **public participation (PP)** as an important prerequisite for achieving sustainable development emerged in the discussion. In particular, Agenda 21 (UN, 1992), the action plan which was the result of the UNCED held in 1992, identifies “information”, “integration” and “participation” as key factors for helping countries to achieve a sustainable development[2]. Indeed, Public Participation can significantly contribute to sustainability, improve the effectiveness of environmental activities, and build the capacity of the actors involved in order to continue the initiative.

After this action plan, a number of laws and international instruments focused on the importance of PP and involvement in environmental decision-making. Nowadays, it is possible to state that the public participation is a well-established concept in the international panorama. Table 1 summarises the main acts referring to this concept.

Table 1: Main international and regional legislations enshrining the concept of public participation

Main international instruments about PP in environmental decision-making		
Type of Instrument	**Year of issuing**	**General content related to PP and articles of reference**
The Biological Diversity Convention	1992	*Recognising* also the vital role that women play in the conservation and sustainable use of biological diversity and affirming the need for the full participation of women at all levels of policymaking and implementation for biological diversity conservation. art 8, j); art 14, par 1, a).
United Nations Convention to Combat Desertification	1994	*Stressing* the importance of ensuring the full participation of both men and women at all levels in programmes to combat desertification and mitigate the effects of drought. Art 3, a); art 5, d); art 9, par1; art 10, f); art 13, par1, c); art 17, par 1, d) and f); art 18), par 2, a); art 19, par 1, a) and c); art 19, par 2, b); art 19, par 3, b) and f); art 21, par 1, d); art 21, par 3.
The Convention on Transboundary Effects of Industrial Accidents	1992	*Ensuring* the provision of adequate information to the public in the areas capable of being affected by an industrial accident arising out of a hazardous activity and its participation in relevant procedures with the aim of making known its views and concerns on prevention and prepared measures Art 9.
The Framework Convention on Climate Change (known as Kyoto Protocol)	1997	*Facilitating* at the national level public awareness of, and public access to information on, climate change. Art 10, e); Art 12, par 9.
The EC Directive n° 11 on Environmental Impact Assessment	1997	*Establishing* procedures for involving the public in the decision process concerning the Environmental Impact Assessment

[2] In particular, Chapter 8 of Agenda 21 is devoted to public participation.

		Art 3 a), art 9 par 1.
The UN Aarhus Convention	1998	*Guaranteeing* the rights of access to information, public participation in decision-making, and access to justice in environmental matters. Linking environmental rights and human rights, the Convention establishes that sustainable development can be achieved only through the involvement of all stakeholders.
The EC Directive n° 60 (known as Water Framework)	2000	*Encouraging* active involvement and ensuring consultation in the whole implementation process of the Directive and in particular in the drafting of the programme of measures.
The EC Directive n° 35 on public participation	2003	*Providing* for public participation in respect of the drawing up of certain plans and programmes relating to the environment.

PP is intended as a process to improve decision-making, by ensuring that decisions are soundly based on shared knowledge, experiences and scientific evidence, that decisions are influenced by the views and experience of those affected by them, that innovative and creative options are considered, and that the new arrangements are workable and acceptable to the public. The commonly agreed view is that co-operative approaches that make participation a rewarding experience are achieving better results than more coercive approaches. Participatory and learning-based approaches to decision-making and management are useful for developing a common understanding of environmental problems and are adaptive processes in which technologies and behaviours are continually reviewed and fine-tuned.

For instance, according to the Guidance on PP in relation to the Water Framework Directive (EC, 2003), some potential benefits of public participation processes are:

- increasing public awareness of environmental issues;
- making use of knowledge, experience and initiatives of the different stakeholders and thus improving the quality of the decisions;
- public acceptance, commitment and support with regard to decision-taking processes;
- more transparent and more creative decision-making;
- less litigation, misunderstanding, fewer delays and more effective implementation;
- social learning and experience.

At the basis of a meaningful participation process there are several important prerequisites such as: providing the stakeholders with complete information; building knowledge about the issue at stake; having the suitable resources to start a PP process; designing a clear time table. In the present context, the participation process is to be used for modelling design. In fact, in the field of natural resources management, there is an urgent need to apply and develop new methodologies for linking formal, analytical tools and more qualitative information, emerging from stakeholders' participatory approaches.

It is of utmost importance to bear in mind that PP is a complex process for which no blueprint exists and therefore it has to be designed according to the needs with the available means and tools.

In recent years, concern about the operational limitations of participative approaches and tools has been expressed, and there is fear that these methods are inappropriate when used in certain cultural contexts such as developing countries (Hailey, 2001). In fact, there are worries that the recent efforts to establish such approaches are merely another level of donor conditionality. Participative decision-making should not therefore be reduced to some formulaic process, but should be rooted in a dynamic relationship of mutual trust and respect. An important principle of participatory process is the incorporation of local people’s knowledge into programme planning. In fact, the articulation of people knowledge can transform top-down bureaucratic planning systems. Although in some cases, participatory planning may more accurately be viewed as the acquisition and manipulation of a new planning knowledge rather than the incorporation of people’s knowledge by projects, it is often the case that the “local knowledge” and “village plans” produced through participatory planning are themselves shaped by pre-existing relationships (e.g. by patronage type relationships between as a project organisation and tribal villagers.). Participatory approaches can be easily used to represent external interests as local needs, dominant interests as community concerns and so forth (Mosse, 2001, in Cooke and Kothar, 2001). Therefore, participatory processes, instead of increasing the involvement of socially and economically marginalised peoples in decision-making, can favour the illegitimate and unjust exercise of power (Hailey, 2001). Another shortcoming of participation is that it can often be interpreted as indication of good decision-making, without however really influencing the process. In most cases, participation is a political value to which institutions will sign up for different reasons. Government agencies use participation to reach expenditure targets through enrolling NGOs or community institutions in implementation, public work agencies view participation as a means to reduce operations and maintenance costs; marketing agencies may see participation as a means to enhance an organization’s profile or the seed for future markets; while for NGO participation may mean patronage and consensus-building (Mosse, 2001, in Cooke and Kothar, 2001).

Thus, although there is wide consensus in viewing PP as both a right and a practical necessity, its forms, mechanisms and functions need to be carefully shaped, to avoid its potential negative consequences (Dalal-Clayton and Bass, 2002). It is of utmost importance to design any participatory approach carefully, taking into consideration all the potential negative effects and the shortcomings which can follow, and implementing measures to mitigate them.

3 Actors identification

3.1 Why is actors’ identification important?

Generally, the identification of actors (stakeholders/experts) is a precursor and fundamental step in order to carry out a participatory decision-making process. The transparency of the process should be guaranteed in order to make it more reliable and less vulnerable to criticism. The use of scientific methodologies, which allow the identification of the actors to be involved in the process assuring the objectivity and impartiality of the choice, and help in managing their relations, should support the definition of more sound participatory approaches.

There is often confusion over the terms stakeholders, public, decision makers, etc. The definition provided in the European context by the WFD (EC, 2003) are reported in Table 2. Stakeholders are considered those who have an interest in a particular decision, either as individuals or representatives of a group. This includes people who influence a decision, or can influence it, as well as those affected by it. On the other hand, experts are researchers, professors, and practitioners who have a specific expertise on the issue at stake.

The identification of stakeholders in a specific situation can be performed by means of a **stakeholder analysis (SA)** which, in addition to providing an overview of all the relevant actors in the field of interest, allows:

- identifying the key stakeholders to involve in the participatory process;

- assessing stakeholders' interests and influence and the ways in which those interests affect the decision-making process;
- identifying, in a qualitative way, the relationships between stakeholders.

Table 2: Actors in the WFD (Source: EC, 2003)

(General) public	One or more natural or legal persons, and, in accordance with national legislation or practice, their associations, organisations or groups (SEIA Directive (2001/42/EC). Aarhus Convention, Art. 2(4)).
Interested parties / stakeholders	Any person, group o organisation with an interest or "stake" in an issue, either because they will be directly affected or because they may have some influence on its outcome. "Interested parties" also includes members of the public who are not yet aware that they will be affected (in practice most individual citizens and many small NGOs and companies).
Broad public	Members of the public with only a limited interest in the issue concerned and limited influence on its outcome. Collectively, their interest and influence may be significant.

In the NetSyMoD approach, a simple methodology is proposed for the identification of stakeholders/experts. The main aim is to map all the actors potentially related to the issue at stake in the case of stakeholders' identification, or all the experts in relevant fields in case of experts' identification. This is the preliminary step which, coupled with the Social Network Analysis (SNA), allows to understand the connections between the selected actors, and to identify only the key stakeholders/experts to be involved in the core of the participatory modelling process.

3.2 The process of identifying actors in the context of the NetSyMoD approach

The approach here proposed is flexible enough to be applied in a variety of contexts and at different scales, and is at the same time rigorous to reduce the risk of omitting important actors in the participation process.

The first step is to draft a list of all the stakeholders/experts with a potential interest in the issue under investigation, and to compile their profile. Within the NetSyMod framework, this first task is carried out in a **brainstorming meeting** (**WS1**) by an *ad hoc* **task force group** (**TFG**), which will also have the role of overseeing and steering the whole process A team approach is likely to be more effective and, above all, more reliable than a single individual doing the identification process. A team can compensate for, and neutralise, individual biases, as well as provide a more objective perspective of stakeholders/experts position and interests.

The task force group should include **insiders** – that is, actors directly involved in the process, familiar with it, or with specific expertise of relevance – and **outsiders** – people who are not familiar with the issue, but who can provide more objectivity, as well as fresh perspectives, mitigating the potential biases emerging from insiders' pre-existing relationship with experts and stakeholders. The usefulness of involving outsiders in the TFG is limited in the case of experts' consultation, and may thus be omitted without the risk of biasing the process. One or more **facilitator(s)** are then needed to support the TFG, and analyse the outcomes of the brainstorming exercise. The facilitator's role is crucial for providing a correct and effective management of participation, even in these early stages.

Although some literature suggests the involvement of up to 10 persons, for the sake of efficiency in the management of the meeting within the NetSyMod context it is suggested to keep the size of the TFG below this number, with a minimum of 4 members.

During the brainstorming meeting, the first objective is to specify the decision context, and to draft a list of criteria defining the boundaries of the actors' set, a necessary step prior to the compilation of the actors' list.

These criteria (ad hoc boundaries) differ according to whether the TFG is identifying stakeholders or experts, since the involvement of the two groups drives to different outcomes. In the case of expert identification the *ad hoc* boundaries depend on several factors, such as the scale of the issue under investigation. It is always good practice to include a good mix of experts with a strong scientific background, and also those with sound empirical knowledge. Examples of criteria for the identification of stakeholders or experts are presented in Table 3.

Table 3: Examples of criteria for defining ad hoc actors' boundaries

Stakeholders' boundaries	**Experts' boundaries**
List all actors (public institutions, NGO's, etc) which are directly or indirectly affected by the decision.	List all those who have published in scientific journals more than *n* papers on the subject in the last five years.
List all actors which are directly or indirectly involved in the decision-making process, at all scales of governance (national, regional, local).	List all those who have participated in research projects, whose subject corresponds to the one under discussion.
List all the actors which may gain or lose as a result of the decision taken.	List those who have been cited by other researchers in articles of selected journals.
Group stakeholders according to different categories (e.g., decision maker, user[3], implementer/executive[4], expert/supplier[5]).	List all those who have had consultancy works on the subject under consideration in the last five years.
	List all those who have been awarded contracts in the field of interest in the last five years.

In order to help the TFG to start the brainstorming exercise, the facilitator could write a list of questions related to the criteria on a board, thus facilitating the focalisation of the problem. At this stage members of the team are required to individually identify groups or organisations rather than specify contact persons. Checklist questions can be used at the end of the exercise, with the help of the facilitator, to ensure that members of the TFG are satisfied with their lists (e.g., do I have the ones that benefit and the victims? etc). Once checked, the individual lists can be consolidated and agreed upon by the team. It is in this final stage that contact persons should be identified by the group, and with the help of the facilitator.

One potential obstacle that needs to be taken into account, especially when consulting experts, is that the process of finding a suitable date for the TFG meetings may be time-consuming. Moreover, researchers should be aware of the potential competition existing among experts: this should be kept to a minimum, in order to avoid a situation in which experts are not willing to speak their mind in front of whom they perceive as competitors. The information gained through carrying out the SNA will help minimise this risk.

During the meeting, members of the TFG could also compile preliminary **stakeholder/expert profiles**, based on a well-specified profiling form (an example is presented in Table 4). In the case of stakeholders, it is the organisation and position of actors that need to be profiled. The exercise allows TFG members to gain a better understanding of the reference group, as well as helping them

[3] Stakeholders which use the result of the decision or are affected by it.
[4] Stakeholders that have to implement the decision or its results.
[5] Stakeholders which supply information, expertise or means necessary to the decision-making process.

ensure that all key aspects and roles of the decision-making process have been considered. This exercise may be undertaken in a plenary session with the support of the facilitator.

Table 4: Stakeholders/Expert Profiling Form

Stakeholders:	**Experts:**
Name of the organisation, name of the representative that should be contacted and his/her contact details.	*Name of the expert, nationality, age, occupation, affiliation, working place.*
Interests with respect to the decisional process under investigation	
What are the specific interests of the stakeholders in the decision at stake? *What is his/her position with respect to key issues?* *Which are the actual and potential, direct and indirect benefits or disadvantages for the stakeholder? Does it agree or disagree with the decision at stake?* *What are stakeholders' goals, expectations and values? Etc.*	*Description of the actor's specific interests and relevant expertise.* *Is he/she teaching this subject? Is he/she working on specific research project about this subject?*
Influence	
The ability of the stakeholder to influence the decision-making process. What are this stockholder's resources, legal or moral authority? Can the stakeholder significantly affect the decision-making process? Which is the specific role of the stakeholder in the DMP? Can the stakeholder reach large numbers of influential people?	*At the moment is the expert influencing or has the expert influenced in the past the formation of some national or international policies about the subject at stake?*
Status	
What is the position of this actor in the community? Is the stakeholder a governmental agency, non-governmental organisation, sanctioned, unsanctioned, formally or informally organised? At what level does it operate? What is the place on the organisational and institutional map?	*What is the position of this actor in the scientific national or international panorama? How long has s/he been working in this field?* *Description of the expertise on the subject under consideration. Has he/she a specific education about this subject?*
Strengths and weaknesses	
Which could be the benefits and the disadvantages of involving this actor?	*Which could be the benefits and the disadvantages of involving this actor?*

There may be cases in which the boundaries of the population are not clear-cut, or easy to delimit using a set of identified criteria. Under such circumstances, there is a specific sampling methodology which can be of use for the implementation of PP within the NetSyMod framework. The **snowball sampling technique** (see, for instance, Varvasosovsky and Brugha, 2000)can be used to complete the list drafted during the brainstorming exercise, making it more sound and reliable and ensuring that all the relevant actors have been included. The basic idea behind this method is that actors are not selected from a sampling frame, but from the linked network of existing members of the sample. This process of sampling continues until the research team is reasonably confident of having identified all main stakeholders.

The snowball technique is generally used for identifying hidden population such as groups whose organisational capacity is limited and who may not be easily recognisable. The sampling process begins with the TFG identifying the "seeds", a relatively small number of people who are the first to be involved in the process. These seeds are then asked to name other actors belonging, in their view, to the same group of interested parties. This will be done through **questionnaire** (**Q1**), which will also be used for collecting data and information useful for the second step of the NetSyMoD approach, the Social Network Analysis, which is described in more details in the next sections. At the same time, additional information regarding the problem specification can be gathered through, for instance, interviews with the identified stakeholders/experts.

It is of the utmost importance to bear in mind that, since all the people in the sample are recruited (directly and indirectly) by the seeds, any small bias in selecting the seeds can jeopardise the whole process.

Another problem of the snowball sampling could be that sometimes it is a top-down approach, especially when the research team works with "decision makers" at national and central level. In this case, it is suggested to undertake this snowball process in conjunction with bottom-up identification strategies.

4 Social Network Analysis

4.1 What is Network Analysis? A brief introduction

As a result of the AI phase, a full list of actors is drawn. In this second phase of NetSyMod, information on these actors is collected. Using an objective and scientifically robust methodology, the data on relations and positions of the identified actors will be analysed, and the results will allow to identify key stakeholders to be involved in the Creative Thinking and System Modelling exercise, provide useful information for identifying the power relationships, the interest groups, and the main conflicts within the network of actors.

Social Network Analysis (SNA) is a framework strategy for investigating social structures, a methodology which enables researchers to translate core concepts of social and behavioural theories into a formal language, based on relational terms. In this way, theories which would otherwise be fuzzy and difficult to analyse can be quantified and explored in a systematic and objective way. Wetherell et al., 1994 provide a useful definition of SNA:

> "Most broadly, social network analysis (1) conceptualises social structures as a network with ties connecting members and channelling resources, (2) focuses on the characteristics of ties rather than on the characteristics of the individual members, and (3) views communities as 'personal communities', that is, as networks of individual relations that people foster, maintain, and use in the course of their daily lives." (p. 645)

SNA provides procedures to determine how a social system behaves, and mathematical and statistical methods to test the validity of theoretical underlying hypotheses of human behaviour and interactions. This section will provide a brief overview of SNA and its techniques, more details can be found in, for instance, Wasserman and Faust, 1994.

In SNA, **actors** can be individuals, groups, corporations, and the like. The important feature is that actors are seen as interdependent and not autonomous, but they are social entities. **Relations ties** establish a linkage between pairs of actors (a *dyad*), allowing them to interact in different ways: relations may, for instance, express the evaluation of actors with respect to one another, or they may quantify transfer of resources between actors; there may be behavioural interactions between actors, or physical connections. In addition to different typologies or relations, we may also have relational ties with different characteristics. For instance, relations may be directed (e.g. node A phones to node B) or undirected/reciprocal (the existence of a specific relation between nodes A and B implies the same relations between B and A). Ties may either be present or absent, or they may have different strengths/values associated with them, etc. Actors and relations together form **networks**: networks, therefore, are the results of a process of defining a group of actors on which ties are to be measured.

The first step in SNA is to specify the unit of observation, on the basis of the preliminary definition of the problem. This involves determining both the entity on which measures are taken, together with the level at which information will be summarised and clear specification of the type of relations to be investigated (what is sometimes called in the literature as “name generator”). It is the theory underpinning the empirical analysis which will direct the researcher with respect to the type of relation/tie to be used.

Table 5: Main data collection approaches

Questionnaires	Should be used when the respondents can answer the questions directly, or when the respondent is a representative of an entity. In addition, questionnaires can also be used to structure face-to-face or telephone interviews.
Interviews	Telephone or face-to-face interviews are often used to gather data on egocentric networks. With this technique, there is a need to identify the right line of questioning, and minimise interviewer bias by providing a standard checklist that should be followed. Open-ended questions should be preferred, as they will provide more information (although at the cost of increased difficulty in codifying the data, and comparing across actors).
Diaries	Actors are asked to keep a diary of their interactions (frequency, type, etc) for a specified length of time. Diaries can provide very reliable information, but they require strong commitment on behalf of the actor.
Direct observations	Can be used in field research when the actors are relatively homogenous, small in number, and have face-to-face interactions. The recorded ties are based on researchers’ impressions, though, and may therefore be more subject to biases.
Cognitive social structure	Measure the perceived relations among actors other than the ones directly observed/interviewed. Respondents are asked to give their opinion on ties among other actors. This method could be used when there is a very small sample, thought to be highly representative of the population of actors.
Experimental methods (e.g. role-playing games)	The researchers observe behaviour of actors in an experimental setting. Actors can either be playing their own role to solve a problem similar to the one they face normally, or they can be assigned a role by the researchers. Experimental methods can be useful at the very early stage of research, when the problem has not been clearly identified, and needs to be further explored.

The next step in a SNA is the choice of data collection techniques. There is a variety of techniques available for the collection of social network data, and the final choice will ultimately depend on the contingent situation (both in terms of the size of the actors' set, the problem to be addressed, and the time and resources available). Most of the information for SNA is obtained by directly questioning/interviewing actors about the ties they form with other actors in the sub-set, or by directly observing their behaviour.

The final step in SNA consists in analysing the data collected. There are many formal statistical and graphical considerations which can be done on data of social networks, and the selection of the most appropriate level of analysis depends on the purpose of the research. The basic idea of network analysis is to characterise the **position** occupied by individual actors within the network – where by position we mean the space in the network as defined by the way in which occupants of a certain position relate to actors in other positions (Wasserman and Faust, 1994). The concept of social position refers to a collection of actors embedded in similar ways in the network, whereas the concept of **role** explores the behaviour expected of a person occupying a particular social position. Social positions and role are characterised often by measures of **centrality** and **prestige** – which can be calculated at the individual level (that is, the location of an actor within a network) or at the group level (that is, the difference in the centrality measures of various actors, defining actors' inequality). Centrality measures allow the identification of important actors in the network, and the power relations amongst actors. Positional analysis has the main aim of simplifying information by representing the network in terms of the positions identified by an equivalence definition and a statement of how these positions are related to each other. There is a need, therefore, to specify the equivalence, i.e. the definition according to which actors will be classified as belonging to the same class. There are different types of equivalence classes, such as Euclidean distance, role equivalence, and structural equivalence… The choice will be dictated by the purpose of the analysis. Finally, networks with valued relationship can also be characterised in terms of their **balancedness**, that is, a network is balanced if actors with the same valued-relationship are related to other actors in the same way.

In the case of SNA for participatory environmental planning, **value divides** must also be identified, together with **value drivers**. The former refers to the existence of large discrepancies in the way that actors value relations and/or issue, whereas the latter is the underlying forces that each actor, consciously or subconsciously, takes into account in reaching their perspective of the value of something in a given set of circumstances. These two values are of significant importance in participatory modelling and planning exercises, as they allow to identify actual and potential conflicts with respect to a decision variable (value divide analysis), and the entry points for modifying actors' views and behaviours (value drivers).

4.2 Social Network Analysis in NetSyMoD

Whereas in Section 4.1 the rationale for carrying out a SNA, as well as the main methodologies available to carry it out, have been briefly outlined, this section will describe more in details the specific steps required within the NetSyMoD framework. Within the proposed methodology, SNA, together with the Actors' Identification exercise, will help organise the problem conceptualisation and building phase and managing stakeholders' interactions during the problem design and conceptualisation phase, ensuring that important actors are not excluded from the process – but also that the process is simplified by excluding those actors whose ideas are similar, and can be promoted by a representative. SNA supports, therefore, an objective and appropriate strategic choice with respect to which stakeholders should be involved. The identification of common grounds and divides is necessary to identify a form of governance under which all the different perspectives belonging to different actors can co-exist. Characterising the power structure prevalent in the selected group of stakeholders, finally, will ensure that the participatory modelling and/or planning process is not hijacked by powerful groups, but rather, is truly representative of the whole sample – and population – of interested parties. Similarly, SNA will provide information with respect to experts' positions relative to the topic under investigation, helping in the drawing up of the roster of experts to use for the assessment exercise through cognitive mapping.

There are three main steps necessary to carry out the SNA within NetSyMod:

1. Data collection: for stakeholders, data collection will entail, on the one hand, the definition of a questionnaire which can be administered either through a mail survey, or through interviews; and, on the other hand, the actual interview and data collection and coding phase. The procedure is less involved when experts are to take part in the exercise, in which case archive records will suffice for building the network, and reduced-form questionnaires can be used to gain a first understanding of experts' view of the problem.
2. Data analysis, which will form the basis for advice to the final step of NetSyMoD. In this phase, actors' equivalence will be assessed to single out those who will be involved in Phase 3 of NetSyMoD. At the same time, a measure of power will be calculated for the selected actors, which will inform the structuring of the Creative Thinking and System Modelling workshop.
3. And finally validation which links back again to the Task Force Group. After validation, the analyses will be organised in such a way that they will be directly useful for the Creative System Modelling exercise, both in its preparatory phase, and for its implementation.

4.2.1 Data collection

The preferred data collection methodology within the NetSyMoD framework is the use of questionnaires, possibly with semi-structured interviews. When experts' opinions and views are sought, archive searches will be used to build the network, while a reduced-form questionnaire will be used to gain a first brush of the problem from the experts' point of view. The data collection methods will be described first in the case of application of NetSyMoD to participatory planning (Section 4.2.2) and then in the case of experts' consultation (Section 4.2.3).

The results of the brainstorming meeting will provide a first list of stakeholders to be considered in the SNA or experts to be consulted, together with the unit of measure, and the specification of the types of relation and information which should be collected to specify the problem. This will inform the design of the questionnaire for data collection, or the archive search for building experts' networks.

4.2.2 Design and planning of the contribution to participatory modelling and the analysis of options through the use of questionnaires

Step 1: Questionnaire design

In general, the questionnaire should be structured with both open-ended and close-ended questions: the former are particularly useful in interviews, as they leave space for the respondent to freely describe his/her experience with respect to the issue. Close-ended questions, on the other hand, are less problematic both analytically, and psychologically, as they minimise biases in responses. A mix of the two is therefore likely to provide more information, with in-built reliability check and balances. As the interviews should not last more than 40 minutes, the questionnaire should be designed to fit within this timeframe.

Before describing more in details the structure of the questionnaire, it should once again be stressed that the purpose of this step in the NetSyMoD methodology is *not* to carry out a full Social Network Analysis of the actors involved in the water management of a particular case study – or of the experts in the field. Many authors (e.g. Kamann, 1993) have pointed out that the main problem in SNA is not so much the data analysis and processing, but rather the data collection phase. But, because in the NetSyMoD participation framework SNA is not an aim in itself but rather a means to support the CSM exercise and to better shape the model, this reliability problem should not be of too much concern.

When the NetSyMoD methodology is to be implemented for participatory planning, the questionnaire should contain at least three sections.

Part 1 – Stakeholders' identification:

Key attributes of the person interviewed should be recorded in this section, including affiliation and role.

Part 2: Stakeholders' relations:

This section is the core of the questionnaire, in that the information gathered will allow the researchers to assess actors' structural equivalence, and power relation. The interviewees will be asked to:

- identify the actors whom they interact with. The questionnaire will use a mix of roster and free-recall, in that on the one hand all the actors identified in the brainstorming meeting will be listed, but the respondent will be allowed to add other important actors whom s/he interacts with on the issue under investigation.
- respondents will also be asked to identify the *type* of relationships existing with each of the actors mentioned previously. Type of relations should include, at a minimum: ask advice from; give advice to; communicate actions; reports. The *frequency* of relations will also be measured, which can be taken as a proxy for relations' strength. To increase reliability and minimise recall biases, frequency should be measured using five-point frequency scales[6], with the time interval depending on the case at hand.

Part 3: Stakeholders' views of the problem:

Part 3 collects information on stakeholders' understanding of the specific decision-making problem, as well as their preferences. The objectives are twofold: on the one hand, to supplement the positional analysis and identify stakeholders with similar or opposing views; and, on the other hand, to support the organisation and implementation of the Scenario Development workshop (if needed) or the Creative System Modelling workshop. Part 3 of the questionnaire is clearly highly specific to the problem being analysed, and it should be structured with open-ended or semi-structured questions. However, it should include information regarding both the problems, and the preferred management responses. When **Multiple Criteria Decision Methods (MCDMs)** are to be implemented in the decision phase a section of Part 3 can be dedicated to the development or consolidation of the list of criteria to be adopted for the final choice and the actor's preferences for their weighting. It may also be important to include questions on respondents' perceived position of others.

Step 2: Interviews or mail surveys

Before the sampling and data collection exercise can start, the NetSyMoD methodology requires the questionnaire developed in the previous step to be tested and, if necessary, refined. As the scope of the SNA questionnaire is, in some sense, limited to supporting the Creative System Modelling phase, expensive and time-consuming focus groups may not be necessary. Rather, the members of the Task Force Group could be used for this purpose as well, or other members of the research

[6] The most commonly used approach to measure the strength of valued relation is to use binary scales, yet this method does not always give reliable results. According to some empirical studies (e.g. Ferligoj, A. and Hlebec, V., 1999, Evaluation of social network measurement instruments, Social Networks 21, pp 111-130.), five-point scale is the most reliable approach. One can also use the line drawing scale (whose reliability is somewhere in the middle) (length of line indicates strength). Ordinal scale seem to produce the best result for reporting strength.

team. Once the questionnaire has been validated with respect to both clarity and contents, the data collection phase proper begins.

NetSyMoD envisages the use of face-to-face or phone interviews, with the questionnaire providing the structure for the interview. A formal letter should be sent to the actor to be interviewed, detailing the reasons and objectives of the interview, as well as informing about general content of the conversation; the letter should be followed up by a telephone call for final appointment (Varvasosovsky and Brugha, 2000). The letter should be signed by the person requiring the participatory modelling and/or planning exercise: this could be either the coordinator of the research group, if the methodology is used for research or academic purpose; or the decision maker who needs to involve stakeholders in water planning. The follow-up phone call should be made by the researcher(s) undertaking the survey and carrying out the actual interview.

In the initial phase, interviews will be conducted with those stakeholders identified by the Task Force Group. Then, as respondents themselves name more and more people who should be involved, these "new" stakeholders will also be interviewed. Note that subsequent questionnaires should include all the names of stakeholders, including those added by earlier respondents. When no new (institutional) actors are mentioned, one can be satisfied that the sample is complete.

The interviewer(s) will use the questionnaire as a checklist and guidelines, but the respondents should be free to add as much information as they feel necessary. In addition, at the end of the questionnaire, the interviewee should be asked if s/he has something to add: this may help discover areas, problems or solutions which had not been thought of. Finally, the interviewer will provide information on feedback mechanisms, and ask respondents if they would be willing to participate in the follow-up Creative System Modelling workshop, should they be required.

4.2.3 Consulting experts

In the case of experts' consultation, network relations can be constructed through a desk review.

Searches will be constructed on two accounts: first of all, the researchers will build network(s) based on history of collaboration of the experts with one another, and with other experts. Collaboration needs not be on issues related to the one(s) under investigation.

For researchers and academic experts, searches in international journal databases will be conducted to identify authors and co-authorships, as well as cross-citations. The selection of the database(s) will depend on the initial roster of experts. For practitioners, on the other hand, a different archive search should be done, utilising projects' database, for instance, or memberships in commissions, professional registers, consultancies works, etc.

The other type of search will be more focused on works related to the issue to be explored in the Creative System Modelling workshop. It will aim at clustering experts according to their view and expertise, again with the purpose of carefully selecting participants representing views as well as fields and disciplines, and avoiding consulting experts who have nearly identical views. This search will be supplemented by a questionnaire, which will be mailed to participants together with information related to the project/topic their expertise is required for. The questionnaire will be structured as Part 3 of the Participatory Planning questionnaire described in the previous section; it will also include a part in which the respondents can add other important actors who have not been considered in the list of experts identified by *the task force group*. Data from the questionnaire will be coded and managed.

4.2.4 Data Analysis

Data analysis for participatory planning and experts' consultation for the purpose of NetSyMoD is very similar, and can be grouped in three different categories. First of all, a graphical representation of the network should be prepared, which will provide an immediate understanding of the structure of interactions and relationship, as well as differences and similarities among stakeholders. Secondly, a positional analysis will be carried out, which will help reduce the size of the group to be involved in the CSM exercise. Finally, measures of centrality will be computed.

Step 1: Graph analysis

The emerging network will be visualised in a graph, where actors (nodes) are represented by points, and relations (ties) by lines – or arcs – connecting the points.

Graph analysis can be done using dedicated software[7], freely available – AGNA (*Applied Graph and Network Analysis*). The software is designed to use mathematical methods for SNA, and returns some basic properties of the graph, such as the network type (directed vs. non directed), data type (binary vs. weighted), number of nodes, number of outsiders (that is, of isolated nodes), and number of edges.

Step 2: Key actors identification

A positional analysis will identify which stakeholders or experts to involve in the CSM workshop. Actors are **structurally equivalent** if they have identical ties to and from all other actors, and on all types of relations – structurally equivalent actors are, therefore, substitutable and, if two or more actors are structurally equivalent, there is no loss in generality in aggregating them.

For the purpose of NetSyMoD, positional analysis should be carried out both on the basis of relations and views of the problem. A "**similarity threshold**" needs to be established by the TFG, which will determine the degree of similarity required for actors to be considered substitutable for the purpose of the Creative System Modelling workshop. Generally speaking, more weight should be given to the view of the problem relative to relational ties in establishing this threshold, and this should be lowered with increasing degrees of controversy of the issue.

Step 3: Power Analysis

The distribution of power determines the synergies and interactions emerging in the network. Some means of analysing network structures will help the researcher – or the policy maker – to identify the strength and direction of identified relations, and to single out those actors who are in a "central" position in the network – that is, those who play a crucial role, and to whose opinion/position the researcher/decision maker needs to pay particular attention to.

Traditionally, centrality measures of actors have been considered as good proxies for power position, such as degree centrality, closeness centrality, and betweeness centrality (Freeman, 1979). These measure different types of power – so, for instance, degree centrality is a good proxy for the ability to communicate *directly* with others, closeness centrality represents independence – or the ability to reach a large numbers of alters while being able to rely on a minimum number of intermediaries – and betweeness centrality represents control over communication – or the ability to restrict communication of others.

However, in communications networks for instance, semi-peripheral actors may be more powerful, as they may be controlling information exchange. It is therefore "not centrality in general but rather certain forms of centrality that are predictive of an actor's power" (Mizruchi and Potts, 1998 p. 355).

For group decision-making problems, which are the natural applications of the NetSyMoD methodology, the choice of the measure of centrality is critical (Bavelas, 1950 Leavitt, 1951 Freeman et al., 1980). It is suggested that, within the NetSyMod application, betweens centrality should be preferred as a basic reference for actors' power, and then, depending on the shape of the network, other measures will be used. The **Bonachich measure**, which is a variation of degree

[7] There is a wealth of software available for SNA analysis and visualisation, such as AGD, RE, Egonet, GraphPlot. A list of available software can be found at http://www.insna.org/INSNA/soft_inf.html.

centrality, will also be calculated, as it is based on the idea that power is a function of how many connections one has, but also how many connections the other actors in the neighbourhood have.

Step 4: Value drivers and divides

The final analytical step of SNA within the NetSyMoD framework relates to the analysis of potential and actual conflicts among actors with respect to the issue at stake (value divides analysis), and the identification of possible entry points to modify actors' behaviour (value drivers). If conflict areas are not identified at the outset, they may prevent the Creative System Modelling exercise to reach its objectives, and the identification of a shared view of the issue.

In order to assess possible conflicts, the main data input will come from the third section of the questionnaire in the case of participatory modelling, and from the pre-engagement questionnaire for the experts' consultations.

Measure of cohesion will be used to support conflict analysis. Actors belonging to highly cohesive groups with respect to the view of the problem will be less likely to develop conflicting views and behaviours, and vice versa. The chosen measure of cohesion is a **weighted distance measure**, which measures the total connections between actors (ties for undirected networks, both sending and receiving ties for directed networks), but connections are weighted by their length (the longer the link, the lower the weight).

4.2.5 Outputs

There are three main outputs from the SNA phase, which will feed back, on the one hand, to the *task force group* for validation. And, on the other hand, will be an input into the preparatory phase for the CSM workshop, both in the application of NetSyMoD to participatory modelling, and experts' consultation.

First of all, a **list of key stakeholders/experts** to be involved in the workshop will be drawn up as a result of the positional analysis of actors. This will both limit the number of participants to a manageable size, and ensure that no important actors are left out of the exercise.

Secondly, the **analysis of power** will highlight potentially problematic actors and relations, whom the facilitator will need to actively manage during the cognitive mapping workshop.

Finally, a **conflict analysis** will emerge from exploring value divides and value drivers, while overall network analysis, coupled with information regarding stakeholders background and affiliations contained in Part I of the questionnaire will support **groups' identification**.

5 Use of creative thinking and system modelling techniques

5.1 Creative thinking and modelling

The third component of the NetSyMoD methodology is the **Creative System Modelling (CSM)** phase. This is a key component that makes use of the Actors Identification and Social Network Analysis outcomes in order to give inputs to the final phase of Analysis of Options.

In this field the international literature is rich, but lacking a reference core of works. There are several reasons for this, such as the relative novelty of the topic, its development in rather distinct research fields (psychology, operation research, physics, natural sciences), all producing many problems in terminology. In the following pages an attempt will be made to provide an overview of the main relevant concepts and definitions adopted for the NetSyMoD developments.

One of the first concepts to be defined is that of **mental models** as distinguished from the usually adopted concept of model, which implicitly refers to mathematical formalisation of real world systems for simulation. There are many assumptions about mental models, and, even though the literature tackling this concept in various scientific fields is vast, the explicit definitions are quite rare. What emerges from the literature studies concerning mental models is that researchers and practitioners employ, to some degree, different techniques for eliciting and mapping mental models based on their own unique definitions. The review of the literature dealing with the definitions of mental models was done by Doyle and Ford, 1998, analysing especially the definitions within the system dynamics and related system thinking literature, thus relevant in the present context, and offered a conceptual definition of **mental models of dynamic systems**. 'A mental model of a dynamic system is a relatively enduring and accessible (conscious), but limited (not too complex to help decision-making), internal, conceptual representation (cognitive structure not a process[8]) of an external system[9] whose structure maintains the perceived structure of that system'. Mental model exists in mind, and an external representation of that model is a **cognitive map** (Axelrod, 1976 Eden, 1994).

The term **cognition** is used in a variety of different ways in the literature (e.g. Bartlett, 1932 Schank and Abelson, 1977). In cognitive mapping techniques, it refers to the mental models, or belief systems, that people use to interpret, frame, simplify, and make sense of otherwise complex problems. These representations of mental models are called **cognitive maps** (Tolman, 1948), scripts (Schank and Abelson, 1977), schema (Bartlett, 1932), or frames of reference (Minsky, 1975). They are built from past experiences and comprise internally represented concepts and relationships among concepts that an individual can then use to interpret new events. This is important because decision-makers have a limited capacity for processing information so that, when dealing with complex problems like innovation, they could rarely process all the information that would be relevant. Because human brain works associatively as well as linearly, the cognitive map shows that the concepts are not isolated, fragmented ideas, but rather they are integral components of the framework and are complementary, connected and interrelated.

Cognitive Mapping (CM) is a general term that applies to a series of methods for measuring mental representations (external representations of mental models according to Doyle and Ford, 1998) and thus functional to the further development of simulation models. Most researchers treat cognitive maps as a tool that can usefully summarise and communicate information rather than as a literal description of mental images (Huff, 1990). In the present case CM provides a means for facilitating the process of participatory modelling and, more specifically, for eliciting knowledge and preferences from actors. CM techniques attempt to describe mental images that subjects use to encode knowledge and information. These techniques aim to provide a tool for revealing peoples' subjective beliefs in a meaningful way, eliciting their preferences, as well as encouraging experts, stakeholders and decision-maker(s) to reveal and reflect on their own perceptions of the decision problem or opportunity. At the same time they are useful to gain insight into the problem from other perspectives, and this may then facilitate the process of decision-making, as well as encourage negotiations and help to reduce conflicts. The next section is dedicated to the CM techniques.

The key actors chosen in the previous steps of the NetSyMoD approach will take part in a workshop (**WS2 or WS3**) where they will apply the CM technique most suitable for the specific case. Many alternative approaches are available, some of them presented in the following sections. For example, when dealing with experts for the elicitation of cognitive maps, techniques based on the Hodgson's hexagons approach (Hodgson, 1992) or one of the many versions of the Delphi technique (Dalkey and Helmer, 1963) can be utilised.

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[8] Cognitive structures store information whereas cognitive processes are the mental operations that transform, elaborate, and reduce this information during decision-making or problem solving.
[9] Mental model that refers to the one's own internal cognitive structure is named *metamodel.*

Another useful concept for NetSyMoD is that of **causal scenarios**, intended as a cognitive structure, studied by Read, 1987 as well as Tversky and Kahneman, 1973 and Kahneman and Tversky, 1982 to aid in making causal attributions or judging likelihood. Within the concept of causal scenarios, Hodgoson (Hodgson, 1992) proposed the **scenario-thinking** concept, which, during the cognitive mapping process, is useful for gathering a wide variety of perspectives from actors. These deeper structures can be modelled with systems methods to help see the dynamics of how different end states might come about. Visual support techniques such as ‘hexagon mapping’ are recommended. These are the facilitated visual scenario methods that in practice enable the scenario facilitator to utilise a broad range of skills, including group dynamics, creative thinking, visual thinking, and scenario content appreciation. The hexagon mapping techniques are compared later on in this review with other techniques of preference visualisation.

5.2 Cognitive mapping techniques in the NetSyMoD approach

Cognitive mapping techniques do not aim to prescribe solutions. In most cases the application purpose defines the context of cognitive mapping definition. The review of CM techniques carried out for the identification of the most suitable approaches for NetSyMoD allowed to provide a ranking of the techniques for preference elicitation reported in Annex 1. The selection criteria were the following:

1. coherence with the other phases of NetSyMoD general framework;
2. simplicity and transparency of application;
3. general feasibility.

The structured comparison of various CM techniques is summarised in Annex 1. . The techniques described in the table are chosen representation for the broad scope of different application approaches and tools. During the process of application the techniques are usually modified by the facilitators to suit the specific purposes and conditions, but they still keep their main distinctive features.

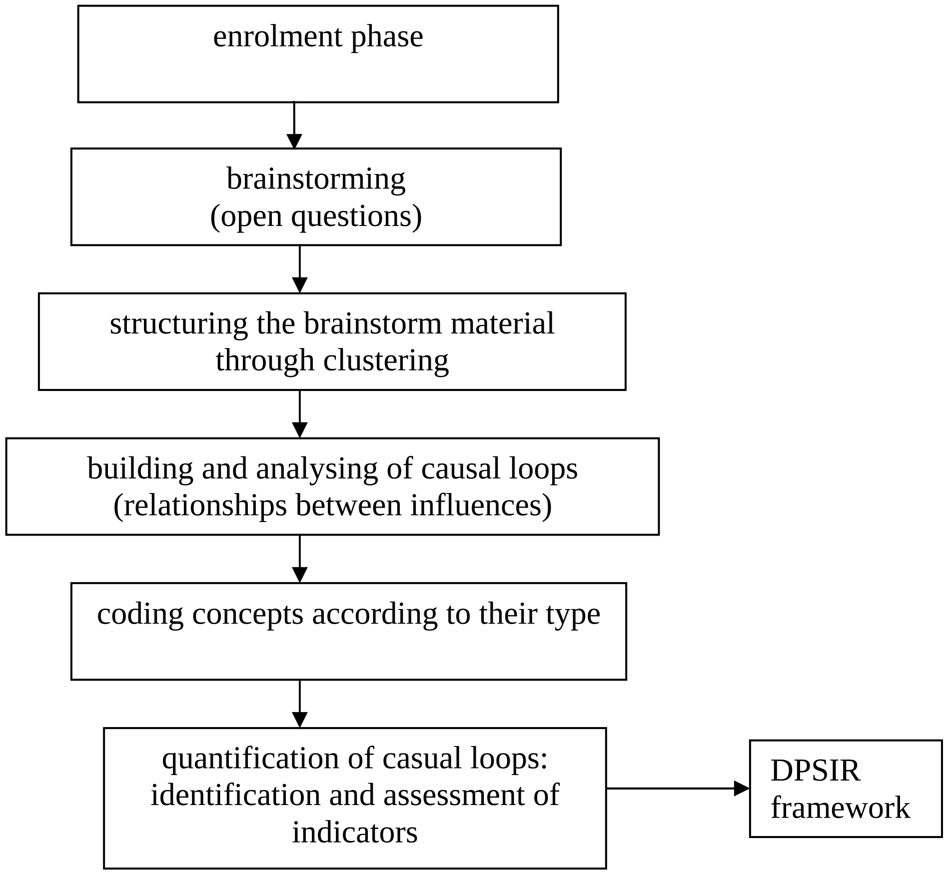
Given the wealth of differing situations that may occur , the identification of a *single* CM technique for the application of the NetSyMoD approach is neither desirable nor feasible. However, according to the two main application typologies and the foreseen implementations, specific and concrete methodological indications can be drawn.

A framework for a proposed experts consultation’s workshop can be found in Figure 3.

For the purpose of NetSyMoD, a simplified **Delphi technique** could be considered for knowledge elicitation when consulting experts. The Delphi method was designed especially for gaining input from recognised sources of expertise and it is a well-structured and transparently organised technique, which encourages independent thinking, and that results in a reliable judgement or forecast. Moreover, the first phase of the NetSyMoD methodology (the careful selection of actors) provides an accurate selection procedure to identify experts, a requirement for the appropriate and useful implementation of the Delphi method.

However, the weakness of the Delphi method is that it is less suitable for face-to-face interactions, and more for the structured questionnaire approach, as it requires time for the questionnaires to be elaborated and given feedback on. For this last reason, in the applications of NetSyMoD the preference can be given to a simplified Nominal Group Technique (NGT), which is based on the Delphi procedure, but uses it in face-to-face meetings that allow discussion between rounds. The fully-fledged NGT entails, as first steps, experts’ identification, and problem specification and definition. In NetSyMoD, this information will be the output of the Actors Identification and Social Networks Analysis, hence the methodology employed to elicit experts’ opinions and knowledge will be greatly simplified, and adjusted to be used in a workshop.

Figure 3: The Diagram of the experts and stakeholders consultation workshop methodology



As an alternative the **Hodgson's hexagons technique** can be applied during the NetSyMoD workshop. The technique allows an interactive creation of scenarios and alternatives. It is relatively simple and has visual advantages for the group working. For this purpose the Creative Thinker software can be used.

While planning a workshop the facilitator must establish a clear set of workshop objectives and should anticipate the potential workshop stages, bearing in mind the ultimate objectives of NetSyMoD. In the enrolment phase, the facilitator explains the CM exercise idea and its goals and introduces participants to the workshop technique by interactive games. During the brainstorming, individuals contribute ideas, either anonymously and simultaneously, or through an open discussion. When up to 50 contributions have been made, the concepts are roughly clustered by the facilitator and shown back to the group. Further concepts are added as participants review one another's contributions and piggyback one another's ideas in a plenary session. Concepts might be clustered and emerging clusters are validated with the group to establish a goal hierarchy and are then further developed. Linking concepts and building causal loops for further evaluation are exploited to initiate discussion around causes and effects and to begin defining a meaning of the problem – this is a very important part of the process. Concepts might be colour coded according to their type (problem, opportunity, strategic aim, etc.); cognitive mapping has no formal coding, rather concepts are coded ad-hoc. Colour coding the concepts helps with visualising or navigating the map and aids memory or thinking processes. In this way the group identifies a set of key concepts and then ranks them by voting to prioritise the issues on which to spend workshop time. Subsequently a quantification of causal loops takes place to allow key indicators to be established, which are the outcome of the CM exercise and will be further elaborated in the *m*DSS module.

For eliciting knowledge in case of the involvement of local actors instead of experts, the most suitable technique within the NetSyMoD approach has been found in the **Hodgson's hexagons**

technique because it is relatively simple to be explained and understood by the group, it emphasises the causal links and ranks the concepts by colour coding that aids visualising the key ideas and problems.

In the previous phases of the NetSyMoD the advisable pre-workshop stages are conducted in which each member of the team is interviewed briefly on his/her initial reactions to the subject, and through open-ended questioning the first layer of deeper thoughts is mapped. This can also be the result of AI and SNA. After the facilitator introduces the main themes, the 'issue conceptualisation' (understanding of the problem) follows. The stakeholders are then given a number of hexagonal cards and they themselves provide the concepts using movable hexagons for capturing data. With the help and guidance of the facilitator, participants group the hexagons. Facilitator provokes exploration of alternative, more adventurous grouping. Relationships are indicated by the 'influence diagrams' with arrows connecting those clustered ideas that are causally related and a sign attached to the arrow states if the influence is positive or negative. Then feedback loops can be created. At any time in the process, blank hexagons can be added to the existing clusters in order to capture newly generated ideas. Then different clusters are linked by 'core ideas' (initially blank hexagons). Concepts might be colour coded in the same way as described in the previous section providing colour balance to ideas. Furthermore, the exercise could result in an output which may be crucial to the wider utilisation of modelling, namely a 'dynamic representation' of the model. In this case the 'idons' (combination of idea and icon) are manipulated, combined and rearranged as a continuous process of formulating thoughts.

5.2.1 Outputs

The main outputs from the CSM phase, which will be an input into the preparatory phase for the Analysis of Options, is the cognitive map (a model). Although cognitive mapping places less emphasis on the formal structure of the decision space model, a well conducted map building session should lead to a model with a structure that can be analysed in a variety of ways (Eden et al., 1992). This includes feedback loop analysis, which can be performed on the whole model or just a subset. Cognitive commitment to the action plan is achieved through developing shared understanding between participants, and emotional commitment through participation in the workshop process.

Secondly, the model emerging from the CSM exercise provides qualitative and/or quantitative indicators to be used and further modified in the Choice phase in *m*DSS. In the case of experts' consultations, the CSM could also lead to a quantification of the indicators, not only to their selection. For participatory modelling with stakeholders, the quantification of the selected indicators will, on the other hand, be done by the researchers' team during the final phases of NetSyMoD.

Moreover, the CSM exercise gives feedback to the AI and SNA phases.

6 Analysis of Options

The multicriteria decision analysis (MCA) comes at the end of the NetSyMoD framework but takes advantages from all the previous steps and their results. MCA is both a framework for a decision analysis, consisting of steps and procedures for a piecewise conceptualisation of problems involving multiple objectives and criteria, and a set of techniques aiming at elicitation, introspection and aggregation of decision preferences. Consequently, MCA represents added value to both (i) the decision process (by helping the decision-maker (DM) learn about the decision problem and explore the alternatives available) and (ii) the decision outcome (by helping elicit value judgements about trade-offs between conflicting objectives). Many techniques focus on the choice, i.e. assuming that the problem has already been defined in sufficient detail in terms of decision alternatives, criteria and actors involved. Only a few methods such as GAIA Ozelkan and Duckstein, 1996, Brans, 2002 and Q-analysis Duckstein and Nobe, 1997 dispose with in-built techniques to support definition/conceptualisation of problem boundary and main drivers. Neglecting a thoughtful problem analysis frequently leads to oversimplification of the problem drivers and subsequently to low satisfaction of the decision aid not matching the needs of policy makers with the yielded results. In NetSyMod framework, this is prevented by linking MCA to the prior steps of the framework.

NetSyMoD is neither the first nor the only approach putting emphasis on the early stakeholders' involvement to explore various viewpoints, beliefs, values, and knowledge related to the problem at hand. A group of techniques called "problem structuring methods" Mingers and Rosenhead, 2004; Rosenhead and Mingers, 2002 came out of the belief that complex problems such as those tackled in natural resource management are intractable, elusive and frequently related to intangible consequence. These problems, referred to also as "wicked" Rittel and Webber, 1973, "messy" Ackoff, 1979 and "hazy" have no objective definition; their description depends on whose perspective is taken into account, and bounded (to some extent arbitrarily) to the chosen set of considered policy options. Cognitive mapping approach, underlying also the NetSyMoD framework, is an alternative yet a similar and complementary set of techniques with similar aim. The reason for choosing cognitive and not problem structuring approach is the emphasis on its ability to surface tacit and deeply held beliefs (mental models) which characterise the group of cognitive mapping techniques. In addition, the combination of mental model elicitation techniques with participatory workshops facilitates social learning among the involved group of actors and favours compromise building and constructive attitude to conflict reconciliation.

MCA represents a formal and prescriptive[10] way to decision analysis and is in many aspects similar to other decision tools such as cost benefit analysis (CBA), operational research techniques (OR), or Bayesian networks (BN) Bromley et al., 2005; Kangas et al., 2000; Katz, 2002 Hauger et al., 2002; Pearce and Howarth, 2000. Common feature of all these techniques is the aid in situations in which pure cognitive decision-making tends to be selective, preferring information which confirms rather than contradicts the belief (susceptible to different biases) and disregarding all but one or two of the most important aspects, anchored to idealised solutions and susceptible to framing effects, prior anchors etc. Buchanan and Corner, 1997; Hobbs and Meier, 1994; Nape et al., 2003. Formal decision analysis surfaces and questions tacit beliefs and makes value judgements and attitudes explicit. But unlike the other techniques, MCA allows for a variety of the decision criteria, and inconsistent or incomplete judgements/preferences to be implicitly considered in the analysis. Contrary to CBA with which some of MCA techniques (especially value/utility function approaches) resemble, the MCA do not attempt to transfer all policy effects into monetary units. The common unit to which all effects are brought is a degree of (subjective perceived) satisfaction of pursed objectives.

Preference analysed by MCA can be imagined as a choice or ranking of alternatives and criteria. They are socially constructed, and they depend on the description and framing of what is being valued, or how the questions are formulated. Prior knowledge, preconceived options, level of understanding of the issue at hand, composition of the interviewed group, level of education may have strong influence on preferences. MCA techniques are suitable to uncover preferences held by individuals and aggregate them across different objectives (intra-personal aggregation) and across different actors (inter-personal aggregation). The full potential of MCA comes in through its combination with deliberative techniques based on an active involvement of all actors. The term deliberation here refers to the style and procedure of decision-making, characterised by mutual exchange of arguments and reflections among all participants invited to deliberate Renn, and a balance-seeking process between conflicting arguments and claims. To this end, MCA is applied in

[10] As opposite to descriptive and normative decision analysis.

the context of NetSyMoD framework in combination with group modelling and creative thinking techniques.

The wide variety of the MCA raises a problem of choosing from many methods. This is important since different methods may (and normally do) yield different results and therefore the decision may depend on the method selected. These differences increase in situations which (i) involve a high number of alternatives or criteria (Jia and Fischer 1993), and (ii) are characterised by strongly held yet conflicting values (Hobbs and Horn 1997b).Bell et al., 2001; Hobbs and Horn, 1997; Hobbs and Meier, 1994. The differences in results can be attributed (at least partly) to the methods' underlying philosophy and assumptions. Which method is more appropriate depends on the set of assumptions that seems most valid for a given situation and person (Bell et al.). However, given the large number of methods available, choosing the most appropriate one is difficult and as a result usually only a relatively small number of methods are applied. The main issue arising when an MCA method is conducted is the extent to which the user understands and feels at ease about the questions an MCA method typically uses to elicit the preferences. In some extreme cases, a decision method uses an approach which does not match the decision-maker's cognitive approach to decision-making Lu et al., 2001; Workman et al., 2003. Consequently he may feel manipulated by the method and so have only low confidence in the results obtained. According to Hobbs and Horn 1997b), the disagreements or inconsistencies between different methods are inevitable and should be welcomed as an expression of the different suitability of a method for a particular situation and a decision-maker. Accordingly, the ultimate aim of MCA is not only to help find a solution to a multicriteria problem, but also to give the decision-maker an opportunity to learn about his/hers own preferences. According to Buchnan (Buchanan 1994b) and Buchanan and Corner Buchanan and Corner, 1997, a good decision aid should help the decision-maker explore not just the problem but also himself. In other words, the process of finding a solution is at least as important as the outcome of the process.

In NetSyMoD framework the MCA analysis makes use of the results yielded from the previous steps: only a representative set of stakeholders is invited to take part in workshop aiming at evaluation of policy options under consideration. During the group modelling workshops, they learned about the expectations and motivations of other participants. This may significantly improve, although never guarantee, the chance of finding a compromise solution everybody is satisfied with. In other words, attainment of unanimity is favoured but not warranted by the deliberative MCA techniques. In addition, at the time of the evaluation workshop, the problem has already been explored in terms of the cause-effect relations; alternative and scenarios identified and decision criteria agreed upon. The specific task of MCA in this context is to weigh policy outcomes against the objectives, balance trade-offs between conflicting criteria, aggregate preference judgements to a policy ranking and analyse sensitivity of the recommended solution. In the case of persistent conflicts even after the deliberative problem conceptualisation, the analysis has to include also conflict mitigation/resolution using inter-personal preference aggregation. The decision analysis is normally carried out during a workshop (second in the NetSyMoD flow) facilitated by a decision analysts or consultant. The success of the workshop depends very much on the ability of the facilitator/moderator to keep neutral position, balance participants' involvement and facilitate consensus (trust) building process. Although the choice of the MCA technique(s) depends on the given context, application of several techniques, discussed earlier in this chapter, may facilitate better comprehension and exploration of the problem at hand.

Similar to the previous stages in the framework, the evaluation workshop may use different ICT tool. In NetSyMoD framework using mDSS is recommended. The mDSS[11] - a generic DSS based

[11] The computer tool (mDSS) is a generic shell providing multiple criteria analysis capabilities for facilitating the use of modelling and the participation of actors in a given decision process. The tool was developed in context of the EU project MULINO (contract No. EVK1-2000-22089).

on multicriteria evaluation - triggers the evaluation of identified policies and facilitates the MCA analysis Giupponi et al., 2004; Rittel and Webber, 1973. Originally built on the Simon's design of decision process, involving "conceptual or intelligence", "design" and "choice" phases Giupponi et al., 2004; Simon, 1960, it further develops to endorse the more iterative and loop-like (spiral) flow of decision process which characterises the NetSyMoD approach. In the current version (*m*DSS 4.0) the software is integrated into the NetSyMoD framework, making use of the analyses (stakeholder analysis, social network analysis and group modelling) accomplished beforehand. From the previous version the close link to the DPSIR[12] framework is maintained. The DPSIR framework allows for a seamless integration of the results yielded during the group modelling workshop, during which the various aspects of the problem at hand are first identified and then connected to intertwined (cause-effect) relations (Figure 4). These relations can finally be brought together to context-dependent cause-effect chains representing the viewpoints of various involved actors. Through aggregation of all actors' viewpoints, a holistic (yet situational but specific to given situation) and multi-dimensional view of causal relationships in human-environmental systems can be obtained. Successively, this is translated into the DPSIR framework.

The DPSIR facilitates the choice of a definite set of alternative policy options from all interventions discussed and pre-assessed during the group-modelling workshop. This set is considered in the subsequent decision analysis. The *m*DSS software does not provide modelling routines (such as those for the simulation of the hydrologic cycle as affected by the alternative options) but facilitates loose coupling and post-processing of model outputs. It provides also a function for full coupling of external models which may be run from within *m*DSS, provided that they comply with an ad hoc communication standard. An analysis matrix (AM) is built at this stage, by processing indicator values to convert spatio-temporal data in synthetic values to be stored in the matrix cells, having with options in the columns and decisional criteria in the rows. The AM thus stores the preferences – performances of the alternative policy options evaluated individually against each decision criterion. At this stage the raw performance measured with different units and/or scales across the criteria is determined.

The mDSS4 allows selecting a choice from several MCA techniques, such as TOPSIS, ELECTRE, VF approach, AHP, OWA and SAW (Table 6, Figure 5). In addition, several techniques for elicitation of weights are included such as pairwise comparison, direct rating and hierarchical weighting. The description of these techniques goes beyond the scope of this paper and is well described somewhere else Belton and Stewart, 2002. Basically, decision rules aggregate partial preferences describing individual criteria into a global preference and rank the alternatives. There is no single method universally suitable for all kinds of decision problems and also in *m*DSS the decision maker may choose the method which best fits his purpose. Very popular decision rules are those based upon additive aggregation, using criteria weights to give emphasis to more important criteria. The decision rules chosen for implementation in the mDSS software are (i) Simple Additive Weighting (SAW); (ii) Order Weighting Average (OWA) (Jiang and Eastman, 2000); (iii) the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) (Hwang and K., 1981); and (v) ELECTRE Bella et al., 1996; Figueira et al., 2005; Mahmoud and Garcia, 2000; Salminen et al., 1998; van Huylenbroeck, 1995.

SAW is the most popular decision method because of its simplicity. It assumes additive aggregation of decision outcomes, which is controlled by weights expressing the criteria importance. OWA is being used because of its potential to control the trade-off level between criteria and to consider the risk-behaviour of the decision makers. Ideal point methods like TOPSIS order a set of alternatives on the basis of their separation from the ideal solutions (see Giupponi et al., 2004 for details). The

[12] Driving Force, Pressure, State, Impact and Response Framework, developed and used by the European Environmental Agency (EEA, E. E. A., 1999, Environmental indicators: Typology and Overview, European Environmental Agency, Copehagen, p 25.) for environmental reporting purposes.

alternative that is closest to the ideal positive solutions and farthest from the negative ideal solution is the best one. These decision rules cover a wide range of decision situations for which they may be applied. The result of decision rules is an alternative option which is recommended to be implemented.

The robustness of the obtained ranking can be analysed graphically and analytically. Sensitivity analysis (SA) follows, to examine how robust the final choice is to changes of uncertainty in indicators' values. The main concern of the sensitivity analysis is oriented to the uncertainty addressing the criterion weights. The *m*DSS tool utilises two approaches for SA: (i) the Most Critical Criterion approach Triantaphyllou, 2000, allowing the identification of the criterion for which the smallest change of current weight may alter the current options ranking; and (ii) the Tornado Diagram that compares graphically each option and shows ranges within which the parameters vary and affect the ranking order.

In response to the end users' request, who were involved since the beginning of the MULINO project, as stated above mDSS is equipped with simple tools to face situations in which several decision makers or different stakeholders are involved. The final phases of group decision-making are supported, which means that it is assumed that a preliminary agreement was previously found in the stakeholders' analysis on a common set of options and criteria. Routines are thus provided to compare the differences between the weights expressed by different decision makers/interest groups. Three options are available: (1) when the differences are small, and the ranking of options does not change, the software proposes compromise weights lying between the indicated sets; (2) when the rankings are different the users can apply a variety of different techniques including weighted average Marchant, 1998, and its modifications, Condorcet winner Gehrlein, 1998, Tataru and Merlin, 1997 to combine them into a single compromise ranking; (3) when the users want to investigate the main discrepancies in assigning the weights among different interest groups, a graphical representation for comparing the weight vectors of different users is provided, to identify the main issues for identifying possible compromise solutions.

Approach	Elicited preference	Underlying principle
Pairwise comparison of option and criteria	Ratio-scale based assessment of options' performance or criteria importance. Originally developed for AHP (Saaty, 1980), popularly used in natural resource management.	$\frac{a_{ik}}{a_{ij}} \in \{9,7,5,....,1/5,1/7,1/9\}$
Simple average weighting (SAW)	Most commonly applied decision rule, popular because of its simplicity. Useful when the performances of conflicting options are expressed in the same units.	$\Phi_{SAW}(a_i) = \sum_{j=1}^{n} w_j \times a_{ij}$
Additive linear value function (LVF)	A value-oriented decision rule based on the assumption that the preferential judgements may be substituted by a number of ('value') preserving the preference relations.	$\Phi_{LVF}(a_i) = \sum_{j=1}^{n} w_j \times u(a_{ij})$
Order-weighted averaging (OWA) (Jiang and Eastman, 2000;Yagers, 1999)	Value-oriented decision rule developed originally as a fuzzy aggregation operator. It provides continuous fuzzy aggregation operations between the fuzzy intersection and union, with weighted linear combination falling midway in between. The rule allows the risk behaviour of decision-makers to be controlled.	$\Phi_{OWA}(a_i) = \sum_{k=1}^{n} ow_k \times b_k$
TOPSIS (Hwang and Yoon, 1981)	Goal-oriented decision rule based on distance measurements from an ideally positive and an ideally negative solution.	$s_{i+} = \left[\sum_{j=1}^{n} w_j^p (u_{ij} - u_{+j})^p\right]^{1/p}$
Critical criterion method (Triantaphyllou, 2000)	Numerical approach to sensitivity analysis seeking for the criterion which may change the alternatives' ranking through the minimal modification of its current weight.	$\frac{(\Phi_i - \Phi_j)}{(a_{jk} - a_{ik})} \le w_k$
ELECTRE	ELECTRE bases on a pairwise comparison of the alternatives. It imposes so-called outranking relation on a set of alternatives. An alternative *a* outranks an alternative *b* if *a* is at least as good as *b* and there is no strong argument against. There is a variety of ELECTRE techniques, from which I think the most widely is the ELECTRE III.	
Borda rule	Voting approach to group decision-making based on the option's rank position in each voter's list.	$\sum_{k=1}^{m} r(a_j \mid A, \succsim_k) \ge \sum_{k=1}^{m} r(a_i \mid A, \succsim_k)$
Additional group rules	Condorcet winner and variations of the Burda rule	
Tornado diagram	Graphical approach to sensitivity analysis by comparison of two options (a basic and a challenging one) at one time. The horizontal bars represent ranges of options' total performance obtained by the variation of each weight.	
Macro criteria comparison	Graphical approach to sensitivity analysis by which the criteria weights are aggregated to a lower number of macro criteria (e.g. environmental, societal and economic criteria) to analyse trade-offs between them.	

a_{ij} .. performance of the option ***i*** with respect to the criterion ***j***
w_j .. weight of the criterion ***j***
$\Phi(a_i)$ .. total performance of the option ***i***
$u(a_{ij})$.. partial value of the option ***i*** with respect to the criterion ***j***
ow_k .. order weight of the *k*-th ranked criterion performance
b_k .. *k*-th ranked partial value of the option ***i***
$r(a_j \mid A, \succsim_k)$ number of options that decision maker ***k*** ranks at most as good as $\boldsymbol{a_j}$

Table 6: ***The* mDSS *decision approaches (decision rules and approaches to sensitivity analysis) and their basic characteristics.***

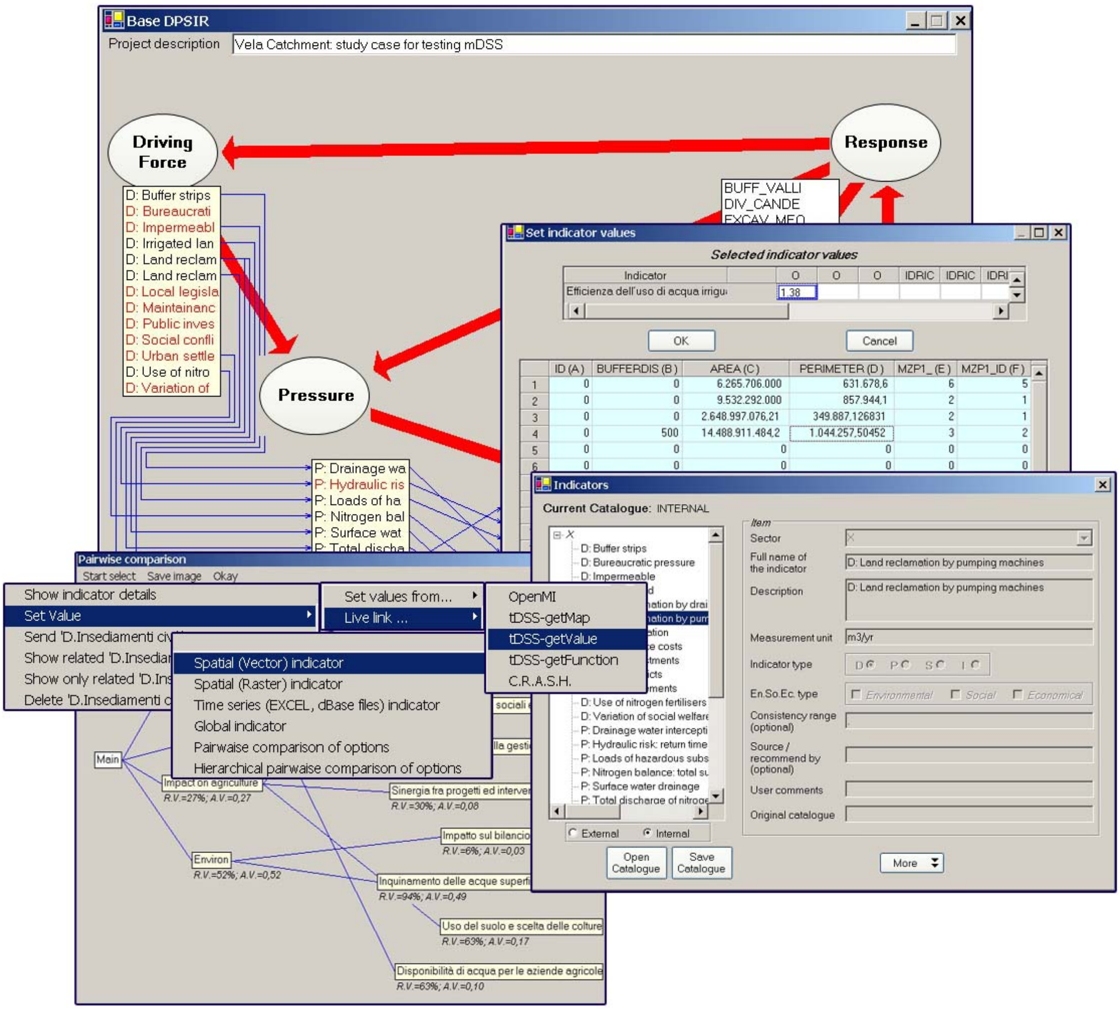


*Figure 4: **Modelling the conceptual relationship according to the DPSIR framework. Results of cognitive mapping methods and deliberative techniques are translated into DPSIR framework which facilitates the pre-selection of policy options and helps to make decision analysis transparent. Indicators chosen from the DPSIR chains fill the decision matrix which is further elaborated by decision techniques. Several ways are available to fill in the decision matrix, including import (and pre-processing) from spatial databases, time series and model output files.***

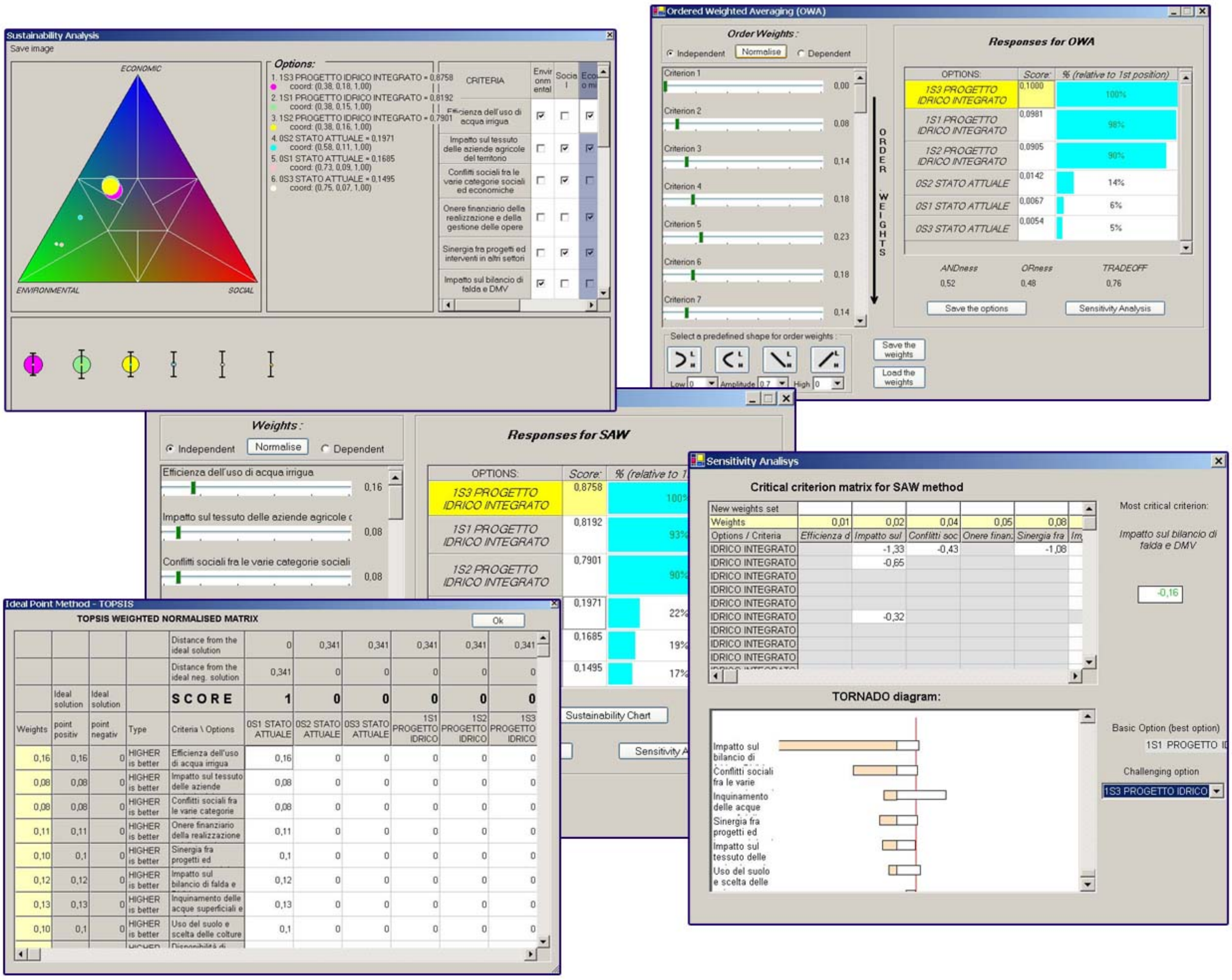


Figure 5: ***Evaluation of measures' performance using multiple criteria decision analysis. Decision matrix is further analysed using different decision techniques, each exploring a specific set of problem features and eliciting individual preferences. Preferably, application of multiple techniques is recommended. Policy ranks yielded by different decisions rules can be further elaborated by sensitivity analysis tools and the module for sustainability analysis. If used in a participatory setting, in-built group decision techniques can facilitate the search for compromise building and conflict mitigation.***

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Annex 1: Cognitive Mapping Techniques

Features	SODA	Hexagons	Viennix	Repertory Grid	DELPHI
Foundations	Strategic Options Development and Analysis Developed over the last 30 years in UK	Hodgson's Hexagon Technique Hodgson, 1992	Vennix's Causal Modelling Vennix, 1996	Repertory Grid Technique Derived from Personal Construct Theory (Kelly, 1955) Developed by Bougon, Weick and Binkhorst (1977) and by Borell and Brenner (1997)	Delphi technique Helmer O., Dalkey N., 1950
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Facilitator	Facilitator has to design and conduct the workshop process. He has a crucial role to select and shape each step of the workshop, since there is no rigorous, step-by-step procedure.	A group will initially often deny any degree of control over external events, but the facilitator can suggest or elicit circumstances that the group might use to influence an event. This will prompt the group to offer alternative scenarios or explanations.	Facilitator has to design and conduct the workshop process.	Facilitator has to design and conduct the workshop process. Successful application of the technique depends very much on the interpretation that relies upon the researchers' power of conceptualisation and the quality of data.	A group of researchers can also play a facilitator's role. Facilitator has to prepare the questionnaires, summarise responses and develop a feedback summaries.
Workshop planning and objectives	While planning a workshop the facilitator must establish a clear set of workshop objectives and should anticipate the potential workshop stages. This process design should be done in negotiation with the client (in	To prepare the workshop each member of the team is interviewed briefly on his/her initial reactions to the subject, and through open-ended questioning the first	No information	An interview to elicit the concepts should be carried out before the workshop. The interpretation process begins during the initial interview.	Selection of the experts and stakeholders that is a key success driver in this method. Problem specification and definition. Elaboration of the questionnaires.

	our case policy maker or authority)	layer of deeper though is mapped individually.			
Brain-storming (open questions) Providing and identifying concepts	During the brainstorming individuals anonymously and simultaneously contribute ideas without seeing each other's contributions. Participants input concepts via their laptops to the model on the facilitator's machine. Stakeholders themselves provide the concepts, ensuring that all concepts are personally relevant. Concepts identified are bipolar (e.g. 'carry on with existing systems' as opposed to 'adopting something new')	After the facilitator introduces the main themes, the 'issue conceptualisation' (understanding of the problem) follows. Than the stakeholders are given a number of hexagonal cards and they themselves provide the concepts using movable hexagons for capturing data.	The heart of the problem is placed on the map, participants are providing concepts about what influences the problem, and what further influences that and so on (they work backwards). Than they work forwards to find feedback.	Individuals are presented with a grid in which concepts are listed in the rows and the columns; concepts are usually drawn from initial interviews with respondents. During interview respondents are free to suggest elements (concepts, solutions, ideas, institutions). Than the constructs of the study are determined: participants make comparisons between elements (using bipolar criteria and i.e. triad method: how much elements differ from one another) and rank them according to the provided criteria (constructs). Outcome: the two-dimensional matrix, constructed of mutually related elements and constructs.	<u>Round one</u> General questions are formulated to gain a broad understanding of the views of the experts relating to the problem and a broad range of opinions for ideas and problem solving. Responses should be collated and summarised. Usually a questionnaire is mailed to the experts. Each participant answers the questionnaire independently and returns it. Than the facilitator summarises responses, develops a feedback summary as well as a second questionnaire for the same respondent group. Based on the responses to the first questions, these questions should dig more deeply into the topic to clarify specific issues.
Clustering - structuring the brainstorm material	When up to 50 contributions have been made, the concepts are roughly clustered by the facilitator and shown back to the group.	Participants are grouping the hexagons. Facilitator provokes exploration of alternative, more adventurous groping.	No information	Hierarchical cluster analysis can be applied to calculate the distance between all the constructs and pairs of elements separately. The results are displayed in 'trees' where the degree of correspondence is expressed in terms of 100% to 0% correspondence[13].	<u>Round two</u> After reviewing the feedback summary, respondents independently rate priority ideas included in the second questionnaire, and then mail back the responses. Again the facilitator collects and summarises the results.
Linking & Causal loops	Relationships are indicated with arrows connecting those concepts that are causally related and a sign attached to the arrow to suggest whether the relationship is direct (i.e. A causes and increase in B) or inverse	Relationships are indicated by the 'influence diagrams' with arrows connecting those clustered ideas that are causally related and a sign attached to the arrow states if	Influence and feedback relations are indicated with arrows and a sign attached to the arrow states the positive or negative	For each cell in the grid the individual is asked to consider the nature of the relationship between the row variable and the column variable and, if it is causal, to indicate this in the cell (e.g. does A	Does not exist in this method.

[13] It is done by calculation of an indegree score and an outdegree score for each variable in the grid. The outdegree score is the number of paths leading from a variable to other variables -measure the importance of variable in causing change in other variables. The indegree score is the number of paths leading to a variable in the grid from other variables - measure how much that variable is influenced by other variables. Grids of different individuals can be summated to allow calculation of indegrees and outdegrees for a group.

	(A causes B to decrease).	the influence is positive or negative. Feedback loops can be created.	relation. Feedback loops can be created.	cause B, B cause A, and is the relationship direct or inverse).	
Reading ideas Contributions	Further concepts are added as participants review one another's contributions and piggyback of one another's ideas. This is done either via a participant's laptop or verbally.	The blank hexagons are added to the existing clusters in order to white on them newly generated ideas. Than different clusters are linked by 'core ideas' (initially blank hexagons).	Participants add further concepts and the model is further developed.	The principal component analysis can be further conducted to discern and name two underlying dimensions. Dimensions are identified by grouping the constructs according to their similarity.	Round three Usually it consists of the final questionnaire which aims to focus on supporting decision-making. But also the process can be repeated until investigators feel positions are firm and agreement on a topic is reached.
Coding concepts according to their type (colour coding)	Concepts might be colour coded according to their type (problem, opportunity, strategic aim, etc.); cognitive mapping has no formal coding, rather concepts are coded ad-hoc. Colour coding the concepts helps with visualising or navigating the map and aids memory or thinking processes. Providing balance to ideas be 'colour balance'.	Concepts might be colour coded according to their type (problem, opportunity, strategic aim, etc.); cognitive mapping has no formal coding, rather concepts are coded ad-hoc. Colour coding the concepts helps with visualising or navigating the map and aids memory or thinking processes. Providing balance to ideas be 'colour balance'.	Does not exist in this method	Does not exist in this method	Does not exist in this method.
Identifying key concepts to be further developed Establishing goals and options Identifying solutions	Emerging clusters are validated with the group to establish a goal hierarchy and are further developed. The group identifies a set of key concepts and then ranks them by voting to prioritise the issues on which to spend workshop time. Than these concepts are elaborated through discussion in order to generate actions statements and finally agreeing a way forward.	From that emerges a filed which may be crucial to the wider utilisation of modelling, namely 'dynamic representation'. In this case the 'idons' (combination of idea and icon) are manipulated, combined and rearranged as a continuous process of formulating thought.	Does not exist in this method	Does not exist in this method	Finally, the summary report is issued to the respondent group.
Weak points	The result of mapping process very much depends on the consultant			Group map is an average of the individual maps; individual differences in cognition which might be very important for the decision-process tend to be	Results depend very much on experts accurate selection Can be time consuming

				obscured in the combined map. A technique is considered to have a limited autonomy as it is best used with other methods such as questionnaires or qualitative interviews.	
Usage, application for SH/ experts workshops	Used primarily in consultant-client situations where consultants are facilitating group decision-making	Recommended for the scenarios developing	Recommended for the scenarios developing	Result in the cognitive matrix that can be explored in both a qualitative and quantitative manner.	Especially for eliciting expertise knowledge, forecasting, innovative planning, policy formulation and decision-making Can be used to reach consensus among groups hostile to each other
Some fields of application	Business management	Business management – building scenarios	Business management	Consumer research, social work analysis, education	Health care industry, marketing, education, information systems, transportation, engineering
Hardware	Single or networked laptops operating specialised software projected onto a shared public screen	Facilitator's briefcase	Facilitator's briefcase	Facilitator's briefcase	The questioners can be e-mailed, no need for special hardware
Software	Banxia Software Ltd http://www.banxia.com/	Creative Thinker CK Modeller	No information	No information	No need for special software
All share	The social element of problem solving; model building; projection and shared space; collaborative dialogue; developing shared understanding and shared commitment				

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