Creative Thinking and Modelling for the Decision Support in Water Management

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Summary

This paper reviews the state of art in knowledge and preferences elicitation techniques. The purpose of the study was to evaluate various cognitive mapping techniques in order to conclude with the identification of the optimal technique for the NetSyMod methodology. Network Analysis – Creative System Modelling (NetSyMod) methodology has been designed for the improvement of decision support systems (DSS) with respect to the environmental problems. In the paper the difference is made between experts and stakeholders knowledge and preference elicitation methods. The suggested technique is very similar to the Nominal Group Techniques (NGT) with the external representation of the analysed problem by means of the Hodgson Hexagons. The evolving methodology is undergoing tests within several EU-funded projects such as: ITAES, IISIM, NostrumDSS.

Keywords: Creative modelling, Cognitive mapping, Preference elicitation techniques, Decision support

JEL Classification: D70, D78, O21, Q0

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1 Introduction

The Network Analysis – Creative System Modelling – Decision Support (NetSyMod) methodology which is being developed in FEEM is intended to become a flexible, but comprehensive methodological framework and a suite of tools aimed at facilitating the involvement of stakeholders or experts in various contexts and in particular in those decision making or evaluations processes characterised by the participation of multiple actors, typically in the field of environmental sciences. An important 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.

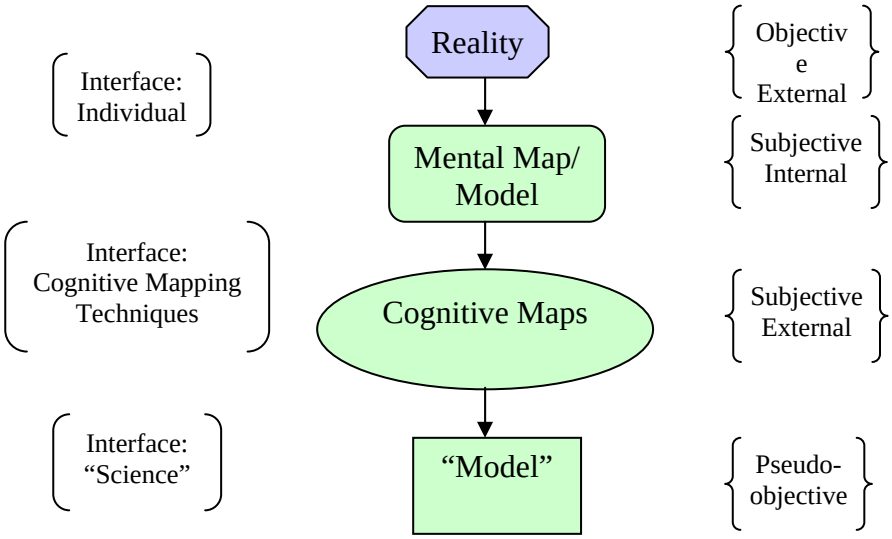
There are numerous examples of dealing with water management problems using participatory modelling approaches (e.g. Exter, Specht, 2003; Belt, 2004). Incentives for public participation with respect to solving water problems indicated in the WFD (EC, 2000) result in the research of Group Decision Support Systems (GDSS). Creative System Modelling attempts to formalise and facilitate the multiple perspectives and knowledge elicitation, which allows structured public participation. In this paper the difference was made between actors such as: experts and stakeholders with respect to the preferences elicitation method, due to existing different group dynamics.

2 Creative thinking and modelling

2.1 Mental models and cognitive mapping

In order to better understand the concept, based on literature studies the relations between reality, mental model, cognitive map and a scientific model can be visualised as on the following graph (Figure 1).

Figure 1: A graph relating reality - mental model - cognitive map and a scientific model



Mental maps / models

The perception of the reality by an individual occurs through ones own **mental map. Mental models** are distinguished from the usually adopted concept of a scientific 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. In fact, it clearly emerges from the literature that different disciplines and even researchers within the same discipline use their own definition of a mental model, resulting in application of different techniques for eliciting and mapping mental models by researchers and practitioners.

The review of the literature dealing with the definitions of mental models was done by Doyle and Ford (1997), 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[1]) of an external system[2] whose structure maintains the perceived structure of that system'. The literature and research base on the subject at stake is vast and applied in various disciplines. K. Craik (1943) expressed the mental model idea, followed by research of Johnson-Laird (1983), application for computer science Norman (1983) and Young (1983), as well as for cognitive psychology and science Sasse, M. A. (1997) and Cañas & Antolí (1998).

Mental model exists in mind, and an external representation of that model is a **cognitive map** (Axelrod, 1979; Eden, 1994).

Cognitive maps

The term **cognition** is used in a variety of different ways in the literature (e.g. Rummerhalter and Ortony, 1977; 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. Sometime a term **concept map** is used for a graphical representation where nodes (points or vertices) represent concepts, and links (arcs or lines) represent the relationships between concepts. The concepts, and sometimes the links, are labelled on the concept map. The links between the concepts can be one-way, two-way, or non-directional. The concepts and the links may be categorized, and the concept map may show temporal or causal relationships between concepts (Plotnick, Eric, 1977). The maps that people create are different due to the generic, social, cultural structures and diverse past experiences.

Cognitive Mapping (CM) was described by Downs and Stea (1973) as a process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls, and

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

decodes information about the relative locations and attributes of phenomena in their everyday spatial environment. It is a general term that applies to a series of methods for measuring mental representations (external representations of mental models according to Ford and Doyle (1997)) and thus functional to the further development of simulation models. Joseph D. Novak (1993) began to study the **concept mapping** technique. His work was based on the theories of David Ausubel (1968), who stressed the importance of prior knowledge in being able to learn about new concepts. Novak concluded that 'meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures.' Concept mapping is a technique used in education, psychology, organisational settings (eg. Nowak & Musonda, 1991; Novak, 1995). It facilitates the creation of shared understanding and reduces the miscommunication between individuals (Freeman, 2004). The technique allows individuals to convey the meaning to others in a visual format and concept maps foster a joint understanding between two individuals viewing the same map (Malone & Dekkers, 1984; Hoover & Rabideau, 1995; Novak, 1998). Other studies on the subject mentioned include Howard (1989), Bergess et al. (1992), Cannon-Bowers et al. (1993), Hinsz (1995), Rowe & Cooke(1995), Glynn (1997), Kraiger & Wenzel (1997), Freeman (2004).

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 form 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 others' 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.

Cognitive mapping techniques for decision making

CM techniques may therefore prove very valuable in structured participatory modelling and planning approaches. Many alternative approaches are available to this end, some of which are 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 (Hogdson, 1992) or one of the many versions of the Delphi technique (Helmer O., Dalkey N., 1950) can be utilised.

Vennix et al. (1990, 1992) and Lane (1993) recognized different ways of thinking along the modelling process, the use of conceptual models was combined with a modification of the Delphi technique in the elicitation of a problem and its conceptualization. In his later book, Vennix (1996) stresses the importance of the facilitation processes and the design of the sessions in tackling "messy" problems with groups of people.

Another useful concept is that of causal scenarios, intended as a cognitive structure, studied by Read (1987) as well as Tversky and Kahneman (1973 and 1982) to aid in making causal attributions or judging likelihood. Within the concept of causal scenarios, Hodgoson (Hodgoson A.M., 1992) proposed the scenario thinking concept, which, during the cognitive mapping process, is useful for gathering a wide variety of perspectives from actors. 'From these perspectives, imagination and logic must be combined to write stories of the future, but in the iterative mode indicating pathways of the events, so that the driving forces could be identified' (Hodgson A., Tait F.) These deeper structures can be modelled with systems methods to help to 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.

Feedback mechanisms and delays between cause and effect can cause non-linear behaviour were researched by Rotmans & Van Asselt (1999). In order to best elicit the knowledge it is important to understand the processes underpinning the decision making. Going from the implicit knowledge to constructed knowledge requires several processes (Beers et al.), namely: elicitation (awaking the implicit thoughts), externalisation (making it visible to others), understanding (shared knowledge), negotiation (reaching common ground through assimilation and acceptance), integration (adding new relation and concepts to the common ground). Externalisation of knowledge is supported by such tools as: the common language, representational technique and carriers like: pen, paper, or software (Beers et al 2002). The effective external representation used while facilitating knowledge elicitation depends on a clearness of represented knowledge and understanding of individual mind maps (researched by Rutkowski & Smits, 2001). Simplicity in formalisation[3] of external representation helps to save an amount of time devoted to a discussion, however if the formalisation is too limited for a certain problem type, it may hinder problem solving and result in counter-productive effects. System dynamics is a formalisation designed to emphasise complexity and and feedback and delays between cause and effect (eg. Rotmans, 1998: Senge, 1990; Sterman, 1994; Vennix, 1996; cited by Beers et al 2002).

Group model building

Reagan-Cirincione et al. (1992) pointed out, among other things, the importance to involve the decision makers in the modelling process and the ability to diagnose a real problem and to match the problem with an appropriate modelling technique. In the paper, they describe a way to tackle complex problems in decision conferences aided by several tools. Richardson & Andersen (1995) have designed 5 different roles during the group model building process. A research developed by Martinez & Richardson (2001), suggest that the preferred mapping tools by the group of highly recognized experts in their sample are the stock-and-flow and causal-loop diagrams.

Experiment done by Hopkins (1987) distinguishes the degree of expertise an individual has about a complex situation by the measured richness of the models that were specified by each individual. Group can improve the model by first seeing the results of the current design. Model building is a long term incremental process.

Andersen (1994) presents very detailed and practical advises concerning group model building for the workshop planning, maintenance based on his various tests. Numerous approaches exist within the systems thinking, soft systems, and system dynamics. Literature for eliciting problem statements from groups, can be also found in "Modelling for Learning," special issue of the European Journal of Operational Research 59(1), "Systems Thinkers, Systems Thinking," special issue of the System Dynamics Review 10(2-3), Randers (1980) and Reagan-Cirincione, Schuman, Richardson (1991) and Lane (1993).

2.2 Review of elicitation techniques

Group elicitation techniques such as: ‘brainstorming’, nominal group techniques (NGT), the ‘Delphi’ technique, must be properly facilitated and appropriately structured. Vennix et al. (1992, 1996) offer an extensive review of literature as well as guidelines to structure the knowledge elicitation process and the elicitation criteria that the model must satisfy. Comprehensive review of elicitation approaches can be also found in Vennix, Andersen, Richardson, and Rohrbaugh (1992).

[3] Set of rules that is followed while making an external representation (Beers et al 2002)

Techniques for preference elicitation from different actors were identified and grouped as following according to their distinctive features:

- Strategic Options Development and Analysis (SODA)
- Hodgson's Hexagon
- Vennix's Causal Modelling
- Repertory Grid Technique (RGT)
- Delphi technique (DELPHI)
- Nominal Group Technique (NGT).

The structured comparison of various CM techniques is presented in Table 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 still they keep their main distinctive features.

The main similarities are concerning the general framework of the elicitation process, in particular all techniques include main phases such as: brainstorming, clustering and analysis of causal loops. The differences are regarding the way the information is gathered, visualised and presented back to other participants. Some techniques are more structured (Delphi, RGT, SODA) than others (Hodgson's Hexagons, Vennix). Some like NGT are more suitable to interactive, face-to-face meetings. Others like SODA and Hodgson's Hexagons use special visual techniques like colour coding for the better analysis.

NGT has not been presented in the table due to its similarity to the Delphi technique. NGT is a structured technique preformed in face-to-face meetings, an effective way to generate a large quantity of creative new ideas and to take decisions in groups meeting face to face (eg. Delbecq, ect, 1975). It is helpful in identifying problems, postulating and exploring policies and problem solutions with stakeholders participation. It includes the following stages: presentation of issue (development of focus/ trigger question), individual reflection and brainstorming (silent generation of ideas and their sharing in a structured way – round robin till all the ideas are recorded and no discussion and justification of ideas), consolidation and review of ideas (discussion and clarification of all ideas), ranking of ideas, compilation of results.

Table 1: Cognitive Mapping Techniques

Features	SODA	Hexagons	Vennix	Repertory Grid	DELPHI
Foundations	Strategic Options Development and Analysis developed over the last 30 years in UK	Hodgson's Hexagon Technique A.M. Hodgson, 1990	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
chosen references	Eden C (1989). Using Cognitive Mapping for Strategic Options Development and Analysis. In: Rosenhead J (ed). *Rational Analysis for a Problematic World*. Wiley: Chichester Phillips L and Phillips MC (1993) *Facilitated Work Groups: Theory and Practice*. Journal of the Operational Research Society 44: 533-549 Pidd M (1996). Tools for Thinking: Modelling in Management Science. John Wiley & Sons: Chichester	Hodgson A.M. *Hexagons for systems thinking*. European Journal of Operational Research 59 1992, 220-230	Jac A.M. Vennix, Group Model Building: Facilitating Team Learning Using System Dynamics, John Wiley and Sons Ltd Hardcover, 1996	Borell K., Espawll M., Pryce J., Brenner S., *The Repertory Grid Technique in Social Work Research, Practice and Education*, Qualitative Social Work, Vol. 2(4): 477-491, Sage Publications, London, 2003	Dalkey, N. C., & Helmer, O. (1963). An experimental. of the Delphi method to the use of experts. *Management Science* 9, 458–467. Rowe, G., Wright, G., & Bolger, F. (1991). The Delphi technique: a re-evaluation of research and theory. *Technological Forecasting and Social Change* 39(3), 235–251.
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 our case policy maker or authority)	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 layer of deeper though is mapped individually.	Facilitator has to design and conduct the workshop process.	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.
brain-storming (open questions) providing and identifying concepts	During the brainstorming individuals anonymously and simultaneously contribute ideas without seeing each others' 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 cause and so on (they work backwards).	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	<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

				mutually related elements and constructs.	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.	Than they work forwards to find feedback.	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[4].	Round two After reviewing the feedback summary, respondents independently rate priority ideas included in the second questionnaire, 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 (A causes B to decrease).	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. Feedback loops can be created.	Influence and feedback relations are indicated with arrows and a sign attached to the arrow states the positive or negative relation. Feedback loops can be created.	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 cause B, B cause A, and is the relationship direct or inverse).	Does not exist in this method.
reading ideas contributions	Further concepts are added as participants review one another's contributions and piggy-back 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).	Further concepts are added by participants 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 'colour balance'. to ideas.	Does not exist in this method	Does not exist in this method	Does not exist in this method.

[4] 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.

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	Outcomes depend very much on the facilitation.	The technique is very much focused on the study of causal-loops.	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 obscured in the combined map. Techniques is considered to have a limited autonomy as it is best used with other methods such as questionnaires or qualitative interviews.	Results depend very much on experts accurate selection Can be time consuming and expensive.
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	Creative Thinker CK Modeller	no specific software	no specific software	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				

In most of the cases the application purpose defines the context of cognitive mapping definition. The described techniques were assessed on the basis of the NetSyMod criteria mentioned below, since the purpose of the review is to come up with the best CM technique for the participatory modelling approach. Constrains and selection criteria for choosing the proper elicitation method were as following:

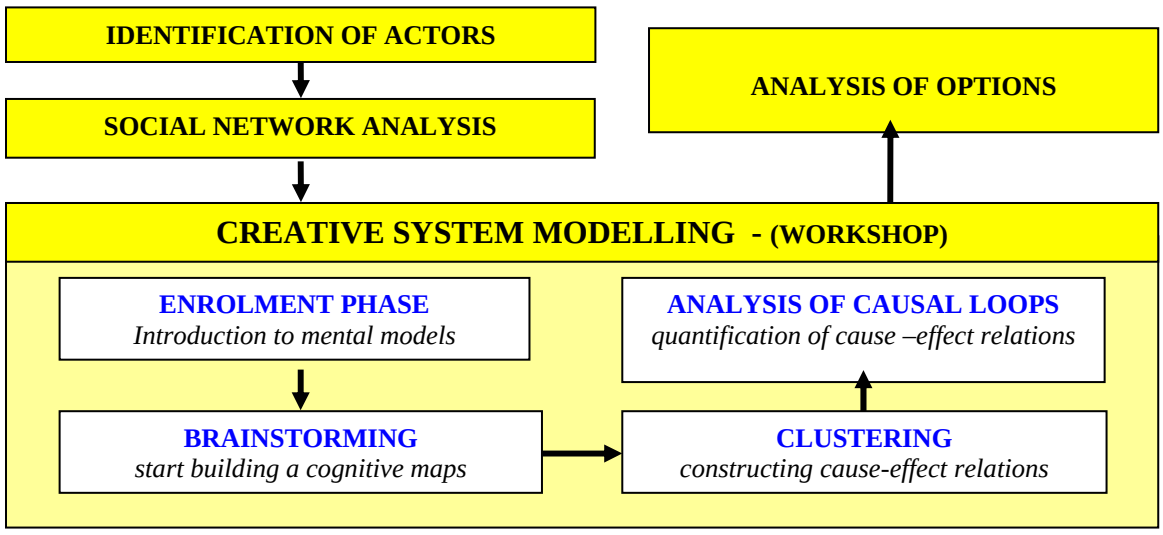
- provision of comprehensive and useful results (determines the effectiveness of the technique);
- coherence with the other phases of NetSyMod general framework (accepting outputs from Actors Identification and Social Network Analysis and providing inputs to the final phase of Analysis of Options);
- simplicity and transparency of application;
- face-to-face interaction and interactive participation of actors in a group model building;
- resources available (financial, personnel, infrastructure) and the costs involved in using various techniques and well as internal capability and management;
- general feasibility.

The review of CM techniques carried out for the identification of the most suitable approaches for NetSyMod allowed to choose technique best for SH preference elicitation, which is the Hodgson's Hexagon Technique as well as one best to work with experts Simplified Delphi/Nominal Group Technique. Their applications are discussed in the following chapter.

3 Application and Discussion

Given the wealth of differing situations that may realise, 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 below.

Figure 2: The diagram of the experts and stakeholders consultation's workshop methodology within the NetSyMod framework



3.1 Experts consultations

For the purpose of NetSyMod, a simplified **Delphi technique** could be considered the best approach when consulting experts, for several reasons. Firstly, the Delphi method was designed especially for gaining input from recognised sources of expertise. Secondly, 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, NetSyMod will adopt instead 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 from 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.

As an alternative the **Hodgson's hexagon's technique** can be applied during the workshop. The technique allows an interactive creation of scenarios and alternatives. It is relatively simple and have 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. Then the problem questions are presented. According to Pidd (1999) 'a well defined problem is half solved' therefore he puts a great importance in the questions formulation. 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 piggy-back of 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 further developed. Linking concepts and building casual loops for further evaluation is exploited to initiate discussion around causes and effects and to begin making meaning of the problem situation – very important part. 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 casual loops takes place to allow key indicators to be established, which are the outcome of the cognitive mapping exercise and will be further elaborated in the mDSS module[5]. Ranking is structured in the way best suitable for further data processing within Analysis of Options matrix.

[5] MULINO DSS - MULti-sectoral, INtegrated and Operational decision support system for the sustainable use of water resources at the catchment scale

Evolving evaluation matrix will emerge after the methodology tests, now designed as a matrix structured of questions, which participants are evaluating in point scale.

3.2 Stakeholders' consultations

For eliciting stakeholders preferences, the most suitable technique within the NetSyMod approach is the **Hodgson's hexagon's technique** because it is relatively simple to be explained and understood by the group, it emphasises the causal links and ranking 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 thought is mapped. 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 it was 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.

4 Conclusions

The main output of the CSM exercise either with experts of stakeholders 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 C., Ackermann F. and Cropper S., 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 (Eden C. 1992).

The model emerging from the CSM exercise provides qualitative and/or quantitative indicators to be used as inputs and further modified in the design of DSS tools. More specifically, the elicited knowledge allows a more informed and accurate undertaking of the Conceptual phase in mDSS, where problem identification, identification of alternatives to address the problem take place; and in the Choice phase, where the evaluation, normalisation and weighting of the multidimensional data take place. In the case of experts' consultations, the CSM could also lead to a quantification of the indicators, not only 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.

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(lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003

(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003

(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003

(lxx) This paper was presented at the 9th Coalition Theory Workshop on "Collective Decisions and Institutional Design" organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004

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(lxxiii) This paper was presented at the 2nd Workshop on "Inclusive Wealth and Accounting Prices" held in Trieste, Italy on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics

(lxxiv) This paper was presented at the ENGIME Workshop on “Trust and social capital in multicultural cities” Athens, January 19-20, 2004

(lxxv) This paper was presented at the ENGIME Workshop on “Diversity as a source of growth” Rome November 18-19, 2004

(lxxvi) This paper was presented at the 3rd Workshop on Spatial-Dynamic Models of Economics and Ecosystems held in Trieste on 11-13 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics

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