MULTI-SECTORAL, **IN**TEGRATED AND **O**PERATIONAL DECISION SUPPORT SYSTEM FOR SUSTAINABLE USE OF WATER RESOURCES AT THE CATCHMENT SCALE

MULINO

Contract no. **EVK1 – 2000 - 00082**
Project Coordinator – Prof. Carlo Giupponi

Social Networks and Water Management Decision Making:

a methodological approach to local case studies

06 - 02 - 04

prepared by

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The work being presented in this report received the contribution of several researchers in the phase of data collection and its preliminary analysis. These contributions allowed the analysis of the five case studies. Beside the authors, other contributing researchers are:

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The active collaboration of end-users and stakeholders was a crucial component in the accomplishment of the analysis

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Introduction

The involvement of state organisms and local communities in the processes of development is a priority for almost all international support programmes. This priority is supported by the perspective that decisions should be taken as close as possible to the affected citizens (the subsidiary principle), as well as by the principles of local participation and decentralisation. It is so, because of the inefficient aspects of current processes of development, which up to a few years ago were very limited in economic terms and somehow rather distant from the local reality (JORGE et al., 2002).

In our time, the concept of sustainable development has inscribed in itself the linkages of economy and environment because the societies base their growth in the extraction, transformation and consumption of natural resources. Therefore, sustainable development demands an integrated and interactive approach that allows for the understanding of the complex relationship between society and nature in respect of human rights, and assuming that environment is one vital dimension of the future of the human kind (LOURENÇO, 2001).

Many environmentalists, like Robert Paelke (1999), see sustainable development as "…an oxymoron, little more than a political cover for otherwise unacceptable corporate environmental practises…". In contrast, others see sustainable development as the basis for a genuine balance between economic growth and environmental values, and even PAELKE (1999) recognises that sustainable development was positively introduced as a "…rebuttal to the common 1970s assertion that zero economic growth was desirable and even inevitable, especially in the long run, given environmental and resource constraints…", and show the evidence that economic restraint, in some context at least, could increase rather than reduce environmental damage. In fact, economic growth provides both environmental opportunities and environmental costs. To achieve the goals of sustainable development it is comprehensible that "…economic growth must remain a legitimate objective of national governments and the world community…" (PEARCE & WARFORD, 1993)[1]. Nevertheless, it is clear now that the former models to pursuit economic growth, which don't give the adequate consideration to the environment, are unlikely to be sustainable. In fact, it is important, at the same time man develops technology, which can enlarge the limits of the carrying capacity of ecosystems, to reduce, by means of effective policies, the patterns of consumption and to adapt practices of conservation of natural resources (BARTELMUS, 1999).

Water management and decision-making

Water constitutes a resource of high economic value for all countries: its use constitutes a means of communication, corresponds to an important factor of production for agriculture, and industry, it is a source of supply for domestic consumption, and the ecological and landscape structures that are expressed in the diversity of the regions depend on it. Moreover, water constitutes a vital resource for human development. With the population growth, there is an increase in need for this natural resource on the planet surface. This growing need, however, contrasts with a limited supply, frequently generating situations of conflict in the demand for water in quantity and quality. It is therefore necessary to look for decision-making tools that allow for an integrated approach in the planning and management of the various types of use of this resource in a given region.

The management of natural resources considered from the perspective of Sustainable Development requires an integrated approach of social, economic and environmental factors. However, all decision-making systems tend to separate these factors at the level of defining planning and management policies.

The use of catchments as territorial units constitutes an effort to apply a truly integrated territory management tool. In fact, considered as territory planning and management units, catchments allow for the integration of geological, ecological and socio-economic dimensions of the territory. Furthermore, these management units allow for the integration of various levels of analysis,

[1] According to the Brundtland Report "…*far from requiring the cessation of economic growth (sustainable development) recognises that the problems of poverty and underdevelopment cannot be solved unless we have a new era of growth…*" (WCED, 1987).

thus facilitating the understanding of the interactions that are established at local, regional and national levels. By using catchments as units of management, a systemic analysis is likewise carried out. The catchment should be seen as a system, constituting various biophysical and social subsystems, which is integrated in larger systems with which various types of interactions are established.

This systemic analysis is fundamental to guarantee the sustainable development of a given region. By 'systemic analysis' we mean an integrated approach that includes natural resources (in this case water resources) as part of functional systems, in which the interactions of biophysical and socio-economic components must be adequately considered, taking into account the long-term management (use, conservation and protection) of this natural resource.

It is not easy to apply these principles. However, the environmental, economic and social costs resulting from the degradation in quality and quantity of this natural resource reveal to us that the application of these principles must not be seen as impossible either. In fact, "...Human communities have already shown their ability to anticipate and avoid environmental problems, once they understand the connection between ecosystem health and integrity and themselves, their children, and grandchildren…" (BRAGA, M., 2000).

At EU level, the Water Framework Directive (WFD) represents the third generation of standards intended to establish common policies and EU laws regarding water resources. Since the 1970's, the EU law system regarding water resources has been characterised by a set of regulations with considerable importance for the improvement of the quality of the water resources shared within the European Union boundaries. The two previous attempts to approach this matter which preceded the elaboration of the WFD (one in the 1970's/1980's[2], and another in the 1990's[3]) can be, more or less, considered as failures. The lack of success in applying them is fundamentally a consequence of the non-fulfilment of such directives by the Member-states of the EU, the considerable deficiencies of the EU law system and the lack of control by the European Commission (INAG , 2001).

However, in 1995, the EU Council and the European Parliament appealed to the Member-states to review the EU water policy in order to create a new framework-directive which should establish the basic principles of a sustainable water policy in the EU. In 1996, the European Commission initiated the process which was designed to create the above mentioned framework-directive, with the purpose of improving and eliminating some of the inconsistencies and shortcomings of the EU law system regarding water resources and to define the principles upon which the common policy regarding the water should be based.

The purpose of this framework-directive, which was approved in 2000[4], was to establish the framing for the protection of interior superficial waters, transition waters, coastal waters and groundwater with view to:

- Avoiding the continuation of aquatic ecosystems degradation, protecting and improving their present condition, as well as the one of land ecosystems and wetland which directly depends on
- the aquatic ecosystems in what concerns its water supply needs;
- Promoting a sustainable water consumption based upon the long term protection of available water resources;
- Reinforcing the protection and improving the water environment, namely through specific measures regarding the gradual reduction of discharges, emissions and losses of primary substances and the suspension or elimination in different phases, of discharges, emissions and losses of such primary substances;
- Ensuring the gradual reduction of groundwater pollution; and
- Contributing to mitigate the effects of floods and droughts

[2] Trough the Directive nº 80/778/CEE, from the Council, published the 15th July 1980; Directive nº84/491/CEE, Directive nº86/280/CEE, Directive nº88/347/CEE and Directive nº91/162/CEE.

[3] Fundamentally trough the Directive 91/271/CEE from the Council, published the 21st May 1991; and the Directive 91/676/CEE from the Council, published the 12th September 1991.

[4] Directive 2000/60/EC of the European Parliament and of the Council of 23rd. October 2000, establishing a framework for Community action in the field of water policy.

The Water Framework directive (WFD) adds a fundamental principle of management to the existing EU law system regarding water resources: that of the hydrographic basin as a management unit, with view to integrating different types of water masses as well as the associated ecosystems which depend on them. This directive stipulates that Member-states must identify the existing catchments within their territory and include them in river basin districts.

The use of catchments as management units confronts us with two different types of questions: questions which regard the conciliation of these with the administrative units, a fundamental aspect for the use of statistic data collected and produced by the different institutions and questions which concern the sharing of water resources. This is the case with international catchments, as the Member-states involved should, in the scope of the WFD, designate an international hydrographic region. Only an integrated approach, bearing in mind the surface waters and the groundwater can respect their natural interaction both in terms of quality and quantity. This integrated approach also implies the association of environmental goals concerning water quality and reduction of pollution at the source.

The European Water Framework Directive (WFD) introduces several innovative concepts for sustainable water management, of which public participation is one of the most important in what concerns the application of the MULINO DSS. Although some provisions concerning public participation are contained in Annex VII A.9 and 11, the starting point for the consideration of participation is found in Article 14 of the WFD which provides that “member States shall encourage active involvement of all interested parties in the implementation of the Directive, not only regarding the development of a river basin management plan, but from the very beginning of the implementation of the WFD (EU, 2000)”. Therefore, the identification and analysis of local networks is of utmost importance task to follow the governance principle displayed on the WFD.

Water management presents specific difficulties due to its various uses and to the important functions that it performs in almost all aspects of human activity. It is not always possible to harmonise the various uses of this scarce resource. Thus the sharing of water resources requires management based on rules that render possible its harmonious appropriation, establishing priorities in use, regulating the interactions of the various social actors (individual and collective), or in other words regulating the conflicts not only among these various actors but also among the various users of the water.

Local participation, stakeholder involvement, and social networks

In a context of economic globalisation it is clear that the linkages of economy and environment, as well as the environmental impacts, are not limited by the boundaries of nation states. Therefore, it is assumed that to correct and solve the environmental problems it is necessary, not only, to correct the economic distortions associated to the inequity of the distribution of benefices resulting from the uses of natural resources, but also to achieve better processes to engage individuals and institutions, at global and local level, in governing themselves. Nowadays the systems that society has developed for governing itself, which are generally based in the nation state, become increasingly complex, and it seems necessary to discuss the basic structures of governance, in order to manage the conflicting and changing economic, social and environmental requirements of modern governance systems. Moreover, individuals, households and communities are seeking greater control over their own destinies, while the boundaries between the public and private spheres are continually shifting (MACHADO et al, 2002).

Therefore, governance arises as a key issue to the implementation of sustainable development. It is an approach to understand and describe the systems, networks, practices and dynamics of governing. Good governance depends on the legitimacy of the political system and on the respect shown by the people for its institutions. It also depends on the capacity of such institutions to respond to problems, and to achieve social consensus through agreements and compromise (MACHADO et al, 2002).

According to Cernea (1985), participation has to do with giving people power to mobilise their own capacities, be social actors instead of passive subjects, manage resources, make decisions and control the activities that affect their lives. This type of co-management requires

power sharing between government agencies and citizens with a stake in the common pool of resources and territory. It emphasizes a bottom-up rather than top-down process of participation and implies user groups playing an active role in decision-making. The local communities of stakeholders should play a central role in identifying resources, defining development priorities, choosing and adapting technologies and implementing management practices.

The participation of local communities involves the different stakeholders present in the region, and therefore applies to an integrated, multi-level and multi-disciplinary approach. The participation in the management of territory and natural resources is justified by the benefits to local communities resulting from the proximity of the local stakeholders to the resources, which could ensure a more adequate use; the expected increase of resource flows to rural populations, which can contribute to alleviate poverty, diversify benefits and achieve a more equitable income distribution; the flexibility of the process, which can ensure a better adaptation to the context of uncertainty and change (BROWN, 1999). However, integrating local people in the decision-making processes is not always a successful process. They should participate in the decision-making process but they must also benefit directly from the decisions taken (CATER & GOODALL 1992).

Structure of the report

The purpose of this report is to provide a methodological approach to social networks analysis in the context of management of scarce natural resources, and to detail some theoretical and practical components about Workpackage 2 of MULINO project. The analysis of the social networks in the five local case studies aimed at understanding the role played by the actors in the decisional context in each case study as well as to engage them on the project activities. To accomplish this, a methodological approach was developed for establishing local networks of stakeholders, DSS users, and research institutions.

The analysis of social networks should be seen as an innovative tool for the participatory management of territory and natural resources, and therefore as a crucial tool for good governance.

The report is structured in four main parts. The first chapter refers to the social network approach. In it, the theoretical aspects of social networks and their significance for the involvement of local actors on the decision-making processes and on the definition of development strategies are presented.

The second chapter presents the methodological approach to achieve the analysis of the social networks in local case studies. The type of data to be collected, the statistical analysis and the graphic visualisation of this type of networks are also highlighted.

The third chapter is dedicated to the presentation of the results of the local networks analysis. The general background of five European case studies is presented. Furthermore, it is made the detailed description of the analysis of the local network identified in the Portuguese case-study area: the Caia River Catchment.

The last chapter of the report deals with the issues of the linkages between the local network analysis and the participatory decision-making, in the frame of a good governance of scarce resources.

1 IMPORTANCE OF SOCIAL NETWORKS

Social networks have a key role in the effective management of territories and resources. These networks should coordinate contact between the various individual and collective actors present in a given region and encourage them work together in order to harmonize their objectives and preoccupations. The success of the local network, as a support instrument for managing the territory and the natural resources, partly depends on the type of participation of the various stakeholders present in the region. Since the various actors find themselves involved right from the beginning of the process, this is a way of ensuring the success of responses by the development and implementation of decision-making support tools. Therefore, the final decision has a greater probability of integrating the expectations of the various actors that have interests at play in the territory.

The relationships among the various social actors (whether individual or collective), in any area, are structured in the form of networks. In reality, "*…the people belong not only to groups but to networks as well, the groups being the reflection of the structural relationships that tie the individuals together…*" (DEGENNE and FORSE, 1994).

According to WASSERMAN and FAUST (1994), a social network consists of a finite set of actors and the relation or relations defined on them. The actors are social entities, discrete individuals, corporate or collective social units. A basic assumption of the relationships formed to provide a network is that the social actors in a network are mutually dependent upon resources controlled by each other, and that there are benefits to be gained by pooling their resources. In a relatively static way, networks can be defined as "*…systems of social actors that propagate among themselves information and resources across structures with strong connectivity with the objective of making common a variety of their internal environment. Aside from this, it is observed that the interactions with the external environment of the network arise from structures with a lesser degree of connectivity…*" (LEMIEUX, 1999).

In the decision-making process, social networks function as an essential tool in the transmission of normative systems, which will regulate the decision and allow for the identification of existing problems and potentialities, the evaluation of the validity of proposals for intervention, and also the understanding of interactions and conflicts among the various social actors, whether individual or collective (LOURENÇO et al, 2001). Thus, it becomes imperative to consider, at local level, the relationships among the various social actors as real interactions and therefore as local potentials and liabilities, thus guaranteeing the success of the decision-making process.

Analysis of Figure 1 shows how the networks that are established at a local level are integrated into larger networks (regional, national, and even international). Moreover, the diagram shows how the networks that are established within the context of the decision-making process are relatively centralised (LOURENÇO et al, 2001). Thus, it can be observed that the transfer of resources and information fundamentally follows a chain, somewhat hierarchical, which encourages top-down communication and makes the reverse more difficult. It is therefore noted that horizontal communication among the various levels of the diagram is of lesser importance, although not non-existent. This fact indicates that we are not in the presence of a *perfect network* in which all the actors are at the same time transmitters and receptors of equal importance.

The diagram implies that in the internal environment of the network there are preferential transmission (and imposition) flows of the normative framework, as all the actors are not of equal position. Nevertheless, this fact does not mean the acceptance of all the decisions, information, or actions transmitted from the higher levels. There can be diversity in perceptions about the potentials and problems of a given region due to the individual actor's proximity to the rational that determines the various activities. These different perspectives may be configured in different views about development.

Thus, it is observed that the social networks are frequently conflicting. The awareness of these conflicts is essential in order to understand the rationale of these networks and to understand where the obstacles to decision-making and implementation of the various policy measures lie. Sometimes the conflict or obstacle arises, not from various perspectives of development, but from a lack of awareness of policy measures, or a lack of adequate training for their correct understanding and effective implementation. In this sense, it is very important to identify and

characterise the various social actors (individual and collective) to understand their functions and levels of intervention, and to comprehend the types of relationships that are found among these actors that comprise the network.

On the other hand, within the context of the management of a finite natural resource, such as water, another significant type of conflict is observed. These conflicts are those among the various uses to which this natural resource is subjected. It is thus important to identify the various water uses of the catchments to be analysed. In the end, this contributes to the identification of the stakeholders, or in other words, the social actors that are found at the base of the local network.

The various uses of water (agriculture, agro-industry, industry, tourism, recreational activities, urban domestic use, etc.) correspond to the various rationales of intervention in the territory, which are important to be aware of and integrate in the local network of support to the MULINO DSS.

In some other cases, it is likewise important to know if the use of water in a particular catchment is made exclusively in the catchment, or if it is to be used in other areas outside the catchment. This is because the development of one region based on natural resources coming from another region could be the source of possible conflicts. This situation, which, at a local or regional level, could be seen in a negative way, provides a rationale for inter-regional solidarity, possible only at a higher administrative level.

Therefore, it can be observed that there is a need to give perspective to local networks within a larger decision-making context, or in other words, it becomes important to understand in what way the driving forces act on the local network.

As for the driving forces, it is necessary to proceed with their identification, both in terms of the internal environment of the network (for example: the main water uses, and the territorial dynamics that exert pressure on this resource), and in terms of those driving forces that determine the way the network works from a point external to the network, i.e., national and supranational normative frameworks.

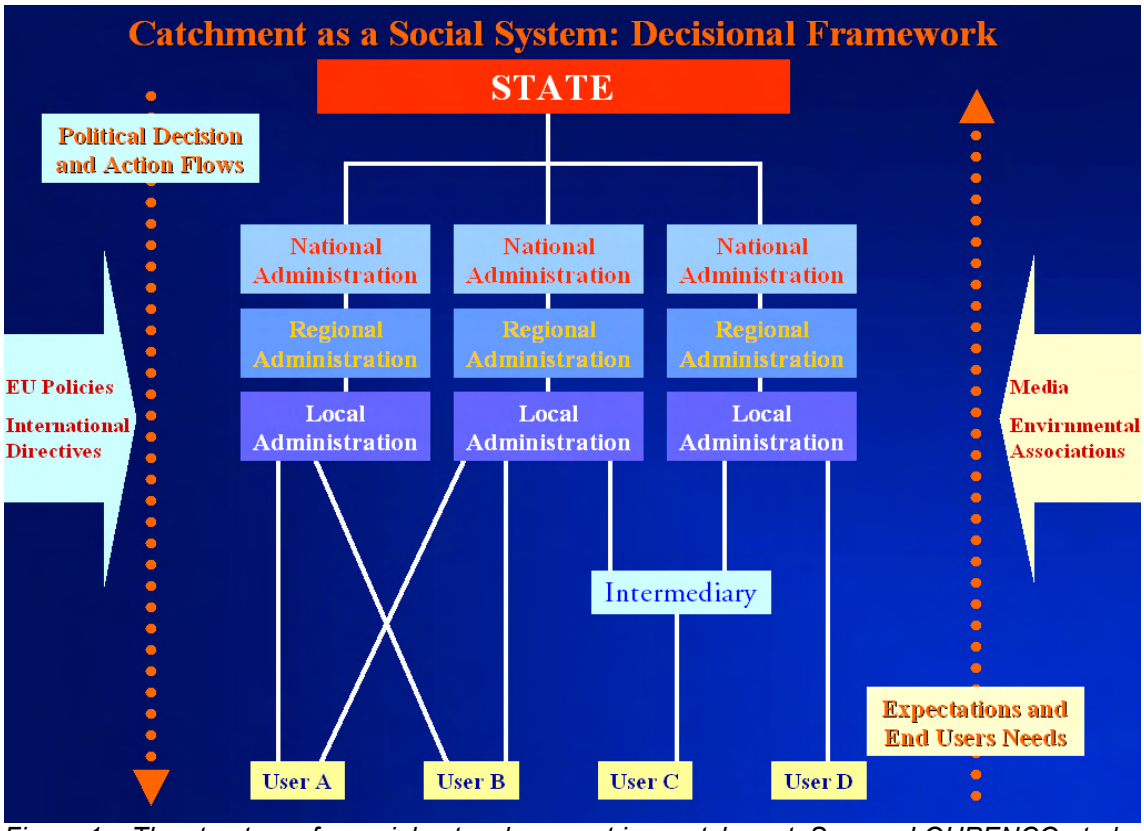

Figure 1 – The structure of a social network present in a catchment. Source: LOURENÇO et al, 2001

These laws may be understood as external factors that influence the behaviour of the network by defining intervention norms and policy measures. They are restrictions that are imposed in general from the highest levels of the social network and to which the lowest levels must adapt.

However, they are not the only external factors that determine how these local networks operate. In fact, depending on the needs, expectations and conflicts of the local actors (water users) sometimes protest movements are generated that have an influence on the network of social relations, encouraging certain decisions and opposing others. The influence from these types of external factors has a direction opposite from that of the normative framework: bottom-up, instead of top-down. Thus, transmission of information and intervention can be observed from the lowest levels of the network moving towards the higher ones. Here it becomes necessary to know about the types of external factors that tend to constrain action, creating difficulties or guiding the process of decision-making along another path. Moreover, it is important to understand the capabilities of water users to organise themselves in group action as well as the efficiency of their organisations.

Therefore, it is observed that although complex, it is not impossible to understand and grasp the way social networks operate. Nevertheless, in order that the MULINO DSS has a high probability of success from the very start, this DSS should take into account the largest possible range of stakeholders that represent the diversity of functions, relations and water uses of the catchment that serves as the case study.

1.1 Social networks analysis

Social network analysis is the measuring and visualisation of relationships and flows between people, groups, organisations or other information/knowledge processing entities. The nodes in the network are the people and groups while the links show relationships or flows between the nodes. Social network analysis provides both a visual and a mathematical analysis of institutions relationships. This type of analysis aims at examining the patterning of the social connections that link sets of actors (FREEMAN, 1979). Actually, this analysis tries to describe

two types of patterns: social groups (sets of actors closely linked together) and social positions (sets of actors who are linked into the total social system in similar ways).

One of the methods used to understand networks and their participants is to evaluate the location of institutions in the network (mainly with the analysis based on the visualisation). Measuring the network location is finding the centrality of a node. These measures help determine the importance, or prominence, of an institution in the network.

When a subject, such as water management, connects organisations, it is a social network. This social network approach facilitates the study of how information flows through direct and indirect network ties, how the stakeholders are linked with water resources and how these institutions operated among the network, if its connector is stronger or weaker.

The social networks related with water management research could concentrates on how the different intensity or communication types might affect the ways to manage more efficiently the water in the catchment.

1.2 Parameters of Analysis

To go further on social network analysis it is necessary to define the fundamental parameters of analysis and the development of the analytic methods. The parameters must be analysed inside the set of relations established among stakeholders. The interesting feature of a relation is its pattern and it may ask whether and to what degree a relationship is transitive. LEVINE and MULLINS (1978) "propose the examination of the logical consistency of a set of rules, the circularity of hierarchy, or the cliquishness of relationship".

Social network analysts look beyond the specific attributes of institutions to consider relations and exchanges among these social actors. The results of the analysis ask about exchanges that create and sustain work and social relationships. The types of relationships based on the water resources subject can be many and varied, and they are defined mainly based on some parameters of analysis, as the centrality, the relations and composition can illustrate it.

1.2.1 Network centrality[6]

This individual unit of analysis of the network provides the location of one stakeholder into the network. The relationship between the centralities of all nodes can reveal much about the overall network structure. A much-centralised network is dominated by one or a few very central nodes. If these nodes are removed or damaged, the network quickly fragments into unconnected sub-networks. Highly central nodes can become critical points of failure.

A network centralised around a few well-connected hubs can fail abruptly if those nodes are disabled or removed. A network with a low centralisation score is not dominated by one or a few nodes. Such a network has no individual points of failure. It is resilient in the face of many intentional attacks or random failures many nodes or links can fail while allowing the remaining nodes to still reach each other over other paths.

1.2.2 Relationships

The relationships are characterised by content, type, direction and intensity. The content of a relationship refers to the resource that is exchanged. Relationships can be directed or undirected. For example, one stakeholder may give technical support to second stakeholders to solve one problem regarding the water supply. There are two relations here: giving support and receiving support. Alternately, stakeholders may share an undirected relationship, i.e., they both maintain the relationship and there is no specific direction to it. However, while they both share the outcomes of the connector, the relationship may be unbalanced: one actor may claim a close relationship and the other a weaker relationship, or communication may be initiated more frequently by one actor than other. Thus, while the relationship is shared, its expression may be asymmetrical.

[5] LEVINE and MULLINS, 1978

[6] See Glossary, for more information about this concept.

1.2.3 Composition

The composition of a relationship, or a tie, is derived from sharing the same subjects: for example, the tie between stakeholders with the same interests about the use of water (ties between different farmer associations), or both stakeholders are water suppliers. Therefore, identifying the social networks to know better how to works the water management inside the catchment it is possible to help to transcend hierarchical or other forms of status barriers (SPROULL and KIESLER, 1991) and to increase involvement of spatially and organisationally peripheral stakeholders in this social networks (CONSTANT and SPROULL, 1994).

2 METHODOLOGICAL APPROACH TO ANALYSE LOCAL NETWORKS RELATED WITH WATER MANAGEMENT

The analysis of social networks followed a methodological approach structured in the next fundamental steps (Figure 2): Stakeholders Definition; Data Collection; Data Treatment; Networks Visualisation; and Local Networks Analysis.

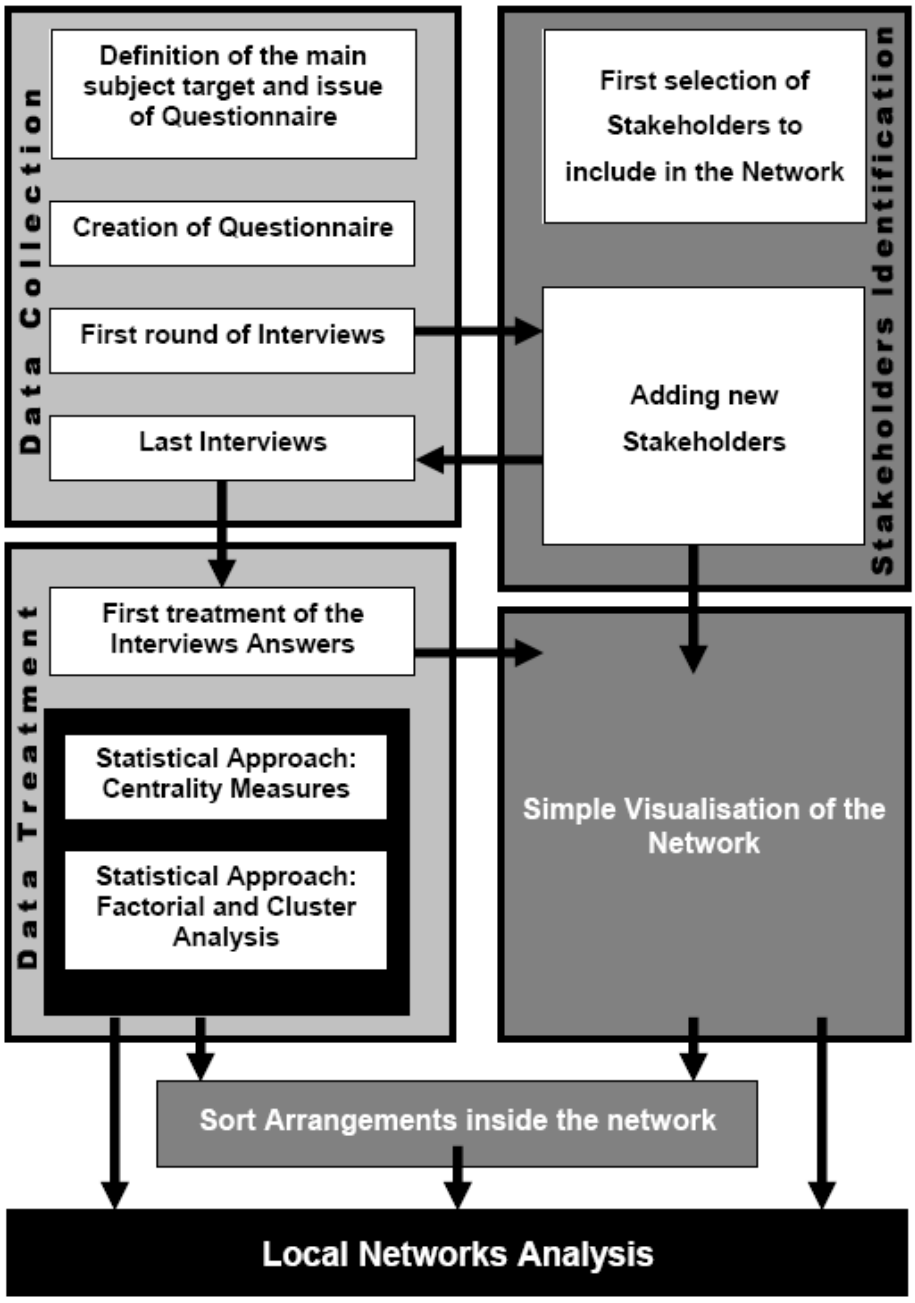

Figure 2 – Methodological steps to identify Caia's Local Networks

As it was referred before, the local network analysis was important to assist the development of the MULINO decision support system. Therefore, to analyse local actors and their interactions, in each study area, was also important to have the contribution of the end-users of this decision support tool.

2.1 Stakeholders Identification and Data Collection

As a first step of this approach, it is important to collect relational data at different levels of analysis, such as individuals, ties, clusters, or whole networks. In a network study, a set of questions is asked to a group of entities (selected based on some pre-defined criteria) in order to generate a list of stakeholders who will compose social network in analysis.

Social network studies have almost never collected information about all the relationships that actors have with all the other members (KOCHEN, 1989) of the social network. Such an effort would be prohibitively expensive. These studies focus on the more relevant relationships of stakeholders with a set of their network members, e.g., those network members who provide a support to the main stakeholder.

In a network study, stakeholders interviewed are often given a list of all the people and entities present in a specific area, and asked to identify a connection of some content. With this procedure, it is possible to increase the initial list of stakeholders that structures the social networks (Figure 2). This process could be repeated in the next interviews, in order to obtain, not an exhaustive list of all persons and stakeholders involved in the water management in the catchment, but the main actors implicated in it. Furthermore, this approach is also useful to start identifying the relative positioning of stakeholders in a network as well as the partitioning of subgroups (HAYTHORNTHWAITE, WELLMAN and MANTEI, 1995).

In the case of a catchment, the geographic boundary is very well defined by the water-divide. However, to understand the process of decision-making (and the behaviour of the social actors involved in it) it is also required to include in the analysis stakeholders that are located outside the river basin. In fact, the administrative units, which regulate the territory management, usually do not follow the physical boundaries of the catchment. Moreover, in some governance systems the water management (or natural resources management) is still much centralised, and therefore, the process of decision-making is lead by entities located outside the catchment. To fully understand the local network functioning, and the decision-making processes, these types of actors must also be included in the analysis.

Information about social networks is gathered mainly by the questionnaire, bibliographic references, statistical inputs and field observations. In these kinds of social network studies, the social actors are often asked to identify the frequency of communication with others as well as the means used for interaction. Questions may refer to a specific relational content such as “objective of the relationships” or “if the stakeholders shared the some position regarding the availability of the water”. In the identification of patterns of the relationships, the interviewees are asked to identify the objectives, type and frequency of relationships with each of the other stakeholders.

Collecting data based on the recall of the interviews, although widely used, is considered by some authors as les reliable than data gathered by direct observation (BERNARD, KILLWORTH and SAILOR, 1981). Those answers are used to rank the relative frequency of contacts with other social actors, and the resulting rank can be biased because not all stakeholders are equally inscribed on the mind of the interviewees (CHRISTENSEN and KING, 1983). Therefore, the combination of data collection methods is (questionnaires, interviews and observation) is considered the best approach by social network researchers (ROGERS, 1987).

The questionnaires are important to define groups of stakeholders and patterns of interactions. In addition to survey questionnaires, the research process has made use of qualitative data gathered through analysis of the interviews and observations. Software applications such as SPSS are useful to organise this data and to investigate patterns among institutions, activities and behaviours. This process provides a way for integrating the analysis of social networks with a cognitive dimension.

Social network questionnaires should not be restricted to asking about relations between stakeholders. These questions are also important to identify groups of stakeholders and patterns of interactions (KIESLER and SPROULL, 1988). These groups of stakeholders attract other actors sharing similar interests, establishing other interactions. Network data is the base to reveal the structure of these relationships and constitutes a support to analyse the implications for the efficiency of water management.

In the frame of MULINO project, the processes of identification of stakeholders and data collection were organised as follow:

Identification of stakeholders to be interviewed: Firstly, to work carefully with e*nd users* to determine high-priority water management stakeholders according some thematic and geographic (if appropriate) diversity. The number of interviews will depend on the level of diversity desired, as with any usability study. However, it is not acceptable to start working with less than eight stakeholders.

Decision about the objectives of the questionnaire and topics to be addressed in it: To choose the main goals of the questionnaire and a reasonable number of topics and tasks that will not exceed the time duration you are asking for (more or less 1h).

Interview guide: Time spent in a stakeholder own environment is precious, and it is necessary to be alert and open to the slight influences affecting their behaviour. The guide document could be the most important issue to obtain best results with the interview, because after any interruption or abstractedness, it could be possible to turn back into the essential. This interview guide is compound by three different parts: one part called head of the questionnaire, with data resulting from the observation and previous data collected based on bibliography; another two parts, with data resulting directly from the interview process (one with open-ended questions and another one with close-ended questions).

Pilot-test the interview guide: As in any verification session, a pilot test is help to identify areas where the flow of questions or activities can be improved.

Administrating the questionnaire: Allow extra time for the possibility that the user is not ready for the interview at the moment that is previous combined. It is also important not exceed the agreed-on time without the interview's permission.

Record the session: Be sure to get the recording permission before to start the interview.

Compile the data: The obtained information will be fundamental at many levels. To compile the data in a way to make easy the next procedures. To define previous a database structure in order to get the main characteristics from the questionnaires to tables.

Report the findings: The interviewer must be prepared to elaborate a report with detailed notes about the interview. The goal is to find other kinds of inputs, extra-interviews, to rich the analysis of the local networks. This kind of rich data you collect in a fieldwork; the analysis of the results will likely raise additional questions. Resume

2.2 Data Treatment and Network Visualisation

The main goals of local networks analysis are: To visualise communication flows and other stakeholders' interactions by using statistical data and diagrams; To examine the factors influencing the interactions; To analyse the association of interactions; To illustrate the implications of the relational data and situations where information flows does not create a formal group structure; and To make recommendations in order to increase the efficiency of decision-making processes by improving the share of resources.

The methodological procedures to achieve the results of network analysis are organised in a sequence of steps of data treatment, which comprise different techniques of multivariate statistical analysis (factorial analysis of multiple correspondences and cluster analysis) to obtain a typology of interactions, and of stakeholders. Then these typologies can be represented by using combined networks visualisation techniques.

2.2.1 Treatment of Questionnaires Data

The purpose of this phase is to organise the data achieved with the questionnaires, and format it, as according with the requirements of the statistical software. The questionnaire applied was structured with two kinds of questions: Close-ended questions and Open-ended questions.

Answers to close-ended questions are previously codified in a task that involves very simple procedures of transferring data to fulfil a matrix of the local network. The process of closing the answers of open-ended questions is more complex. The following steps summarise the main procedures to ensure the quality of data inputs:

- For each open-ended question, it is necessary to create a list of answers and typify them.

- Assign a code for each type of questions in an answers decoder, which is a guide to standardise the process of qualitative-quantitative changing.

The aim of these procedures is to give a measurable dimension to qualitative answers. The procedures of codification have always some problems of accuracy, which are specially related with the codification of open-ended questions. In fact, in what concerns the close-ended questions the errors of accuracy are mainly related with keying mistakes.

According with BERNARD *et al* (1984), to avoid and solve those errors it is important to use one of the several methods to minimise coding errors (Wild Code Checking; Consistency Checking; Selection of a Sub-sample). Furthermore, to increase the objectivity of the interpretations, an *Inter-rater of Consistency Index* (BOURDON, 2000) can be applied. This index evaluates the measure in which two researchers are codifying the answers in the same way based on the same Answers Decoder. However, the accuracy problems related with open-ended questions are more important, especially because they result from the answer interpretation of each researcher. In fact, different researchers can have different understandings of same answer and, therefore, codify it differently.

2.2.2 Statistical approach

According with VALENTE (1995), in the study of social networks two types of approaches can be distinguished, both of them related with the application of multivariate statistical analysis to data sets concerning the social networks under examination.

These two approaches, which allow examining the concepts of role and position of the different social actors within the network, are: Relational Network Diffusion, focusing on the analysis of the direct interactions between the social actors, is expressed by measures of centrality; and the Structural Network Diffusion, which concentrates on the analysis of the actor's position within the social network. This approach is expressed by the multidimensional scaling of networks.

Measures of centrality

The relationship between the centralities of all nodes can reveal much about the overall network structure. A too centralised network is dominated by one or a few very central nodes. If these nodes are removed or damaged, the network quickly fragments into unconnected sub-networks. Thus, highly central nodes can become critical points of failure.

Centrality is a structural attribute of the nodes in a network that refers to the structural position of an actor within the network. Measuring the centrality of the different nodes is a way to assess the importance and influence of an actor with the network. Different statistical methods can be employed to measure centrality. These methods, which run directly over the raw data that arise from the questionnaires treatment, indicate the ability of a social actor to reach the others actors of the network. From the individual measure of centrality, it is possible to estimate a global degree of centralisation of the network FREEMAN (1979).

Centralisation refers to the extent to which a network revolves around a single node. The relationship between the centralities of all nodes can reveal much about the overall network structure. In a star network, the central node has total centrality and all the other nodes have minimum centrality.

The tools to measure centrality are presented in the AGNA (Applied Graph & Network Analysis) software to network visualisation. According to FREEMAN (1979), the three most widely used measures of centrality can answer some questions:

- Degree – How much active is each social actor within the network?
- Closeness – Who is the most prestigious social actor within the network?
- Betweenness – Who is the best-connected social actor within the network?

Multidimensional scaling of networks

As it was said before, besides the actors, one of the fundamental dimensions of social networks concerns the different types of interactions established between those actors. Therefore, the identification of the network structure must take into account of the multidimensional nature of social networks. To define the position of the different actors and the structure of interactions

between groups of actors it is necessary to submit the data matrix, resulting from the questionnaires, to factorial analysis routines and to hierarchical clustering methods.

Factorial analysis

The factorial analysis of multiple correspondences is useful to identify the most significant characteristics of the network structure. Besides, being a first step to refine the analysis, this type of analysis is the most reliable and accurate to deal with the qualitative data resulting from the questionnaires treatment. Resulting from the factorial analysis, a group of factors will be achieved. Being those factors the most significant to explain the distribution inside the initial data sets, and therefore the most useful to the identification of the structures within the social network.

Cluster analysis

The main goal of the cluster analysis is to generate a set of groups (clusters) that will assist the analysis of the structure of the network as a way to organise its visualisation. Therefore, these groups resulting from the cluster analysis will be the base to the sort arrangements of the combined network visualisation. The groups generated by the cluster analysis correspond to the association of social actors that share similar structural properties. For instance, if two actors have identical connections with all the others agents within the network, they will be grouped in the same cluster.

2.2.3 Combined Network Visualisation

To visualise communication flows and other stakeholders' interactions is the main goal of this step of the methodological approach to local networks analysis. The visualisation and the measurement have been central in the growth of local network analysis (CROSBY, 1997). Actually, the visualisation of social networks has provided researchers with a tool, not only to examine network structures, but also to communicate the results to other researchers.

Two distinct ways of display can be used to build images of networks, one based on matrices (Figure 3) and the other on points and lines (Figure 4). In a matrix display, both the rows and columns represent the social actors, and the figures, or symbols, in the cells show the level of connection linking those actors (Figure 3). In the displays based on points and lines, the first correspond to the actors (nodes) and the later represent the interactions among them (ties).

The visual representation of local networks is used to focus at one or both of these two kinds of structural patterning (FREEMAN, L., 2003): some images are constructed in such a way that they emphasise important features of group structure; other images aim at highlighting similarities and disparities in the positions occupied by actors.

	1	2	3	4	5	6	7	8	9
1	0.0	1.0	1.0	2.0	1.0	4.0	1.0	4.0	1.0
2	1.0	0.0	4.0	1.0	0.0	1.0	3.0	1.0	0.0
3	2.0	1.0	0.0	4.0	1.0	1.0	0.0	1.0	0.0
4	3.0	2.0	0.0	0.0	1.0	1.0	2.0	1.0	1.0
5	4.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0
6	5.0	4.0	0.0	4.0	1.0	0.0	1.0	3.0	1.0
7	6.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0
8	7.0	4.0	4.0	0.0	0.0	1.0	1.0	0.0	3.0
9	8.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	0.0

Figure 3 - Matrix of the network

The use of specific software for Networks Visualisation

Classic works of Moreno, Lundberg and Steele or Northway inspired the early visualisation images of social networks. Nevertheless, the development and use of images to visualise social networks have been made through five distinct phases (FREEMAN, 2000): The first phase, during the 1930s, was characterised by the use of graphic images that were produced by hand. These images were roughly improvised, using *ad hoc* rules and much depending of the artistic skill of their creator. During the second phase, in the early 1950s, the researchers start to use

standard computational procedures to produce images. The third phase (during the 1979s) has seen the diffusion of computers, and their use to produce machine drawn images automatically increased. During the 1980s, the fourth phase, the wide dissemination of personal computers stimulated the improvement of images that could be displayed on colour monitors. Ultimately, the fifth phase, which corresponds to the last decade of the 20 century, is related with the increasing availability of web browsers combined with the expansion of the World Wide Web. These circumstances changed completely the opportunities for network imaging.

The software adopted in this study to visualise the studied local networks, can be considered a paradigm of the last phase of development of social networks visualisation. It was chosen after comparing five different packages of free software available on-line. AGNA (Applied Graph & Network Analysis) is a platform-independent application designed for researchers who employ specific mathematical methods, such as social network analysis, sociometry and sequential analysis. Specifically, AGNA can assist in the study of relationships between institutions, their behaviour and organisation.

Sort arrangements inside the Networks

Network analysis is based on studying the patterning of social connections that link different sets of actors. One of the aims is to look for social groups as a collection of actors who are closely linked to one another. The other alternative approach is to look for social positions as sets of actors who are linked into the total social system in similar ways. The network visualisation has been used to call attention to one or both of these two kinds of structural patterning. Some images are constructed in such a way that they emphasise important features of group structure. Other images stress similarities and differences in the positions occupied by actors. Moreover, some images manage to reveal a good deal about both groups and positions at the same time. These kinds of networks images could be created with sort arrangements of the actors based on the cluster analysis results; and supported by the software tools to visualising networks (FREEMAN, 2000).

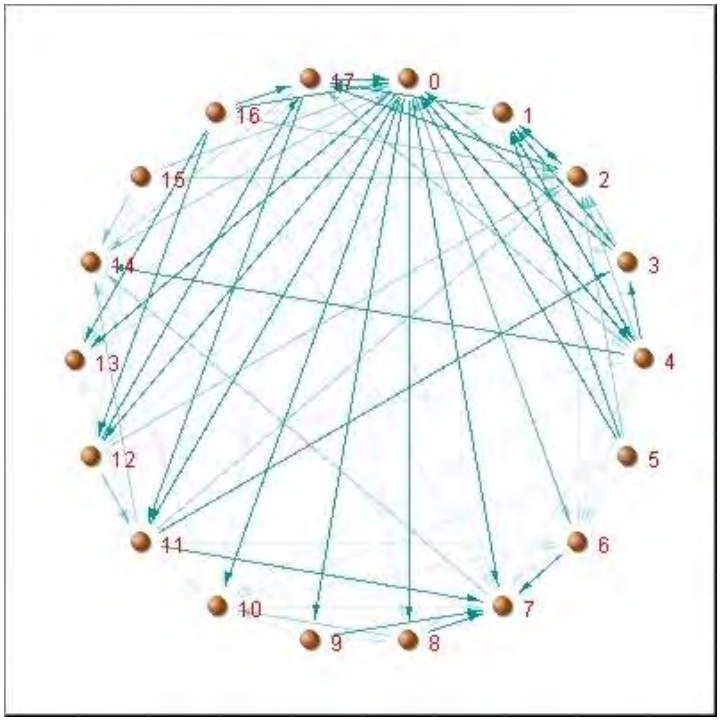

Figure 4- First step of network visualisation

The first steps of network visualisation methodology are based on the groups resulting from the factorial and cluster analysis. The results of factorial analysis are essential to start dividing the social actors (stakeholders) into groups. Each of the first five factors by subject is strongly associated with a different subset of stakeholders. Each one of these factors is used to define a way to find the most significant links to construct clusters. Based on data, coming from most

significant answers, it is formed a set of factors to build the cluster analysis, that are essential to develop sort arrangements. These sort arrangement of points, based on cluster analysis, are the most important statistical support in order to stress particular important features of stakeholders' interlinkages. However, when he had no specific basis for arranging points in one particular form or another we can simply arranged them into a circle (Figure 4).

However, social networks visualisation is not limited to this circular form; this is just the beginning of the sort arrangement processes. It is required to define variations in the locations points to express additional information about the structural properties of social networks. Consider, for example differences between water aims, the image shown in Figure 5. Water demanders are shown as triangles and water suppliers as circles. All the water demanders are drawn on the left part of the image and all the water suppliers are on the right. The different shapes and the placement of points show considerably the separation by actors' responsibilities. Based on this fictional example, only one water demander has a contact with one water supplier, and none of the water suppliers interact with the water demanders.

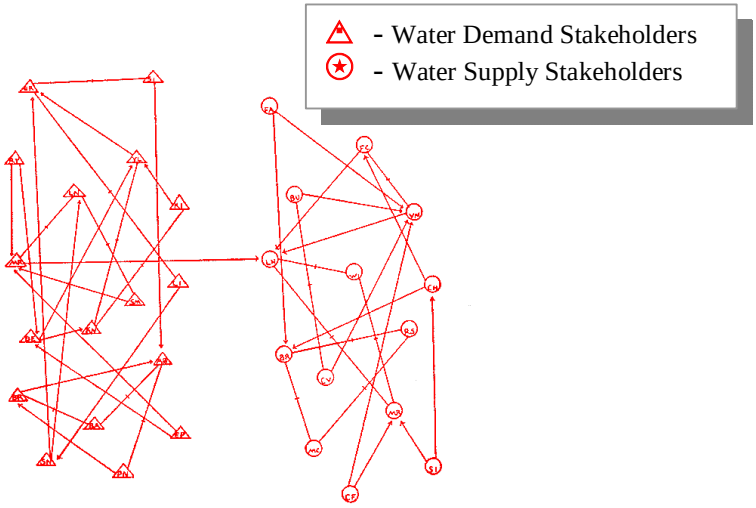

Figure 4 – An example of sort arrangements at the social network (considering only one factor to differentiate the groups of social actors)

During the phases of development of the social networks visualisation, some authors, like Jacob Levi Moreno (1932), applied a number of procedures for the correct construction of social networks images:

- To drew directed graphs;
- To use colours to draw multigraphs;
- To use different shapes of points to communicate characteristics of social actors;
- To show that variations in the locations of points could be used to stress important structural features of the data.

Although many research projects about social networks visualisation have been developed is still possible to see the introduction of innovative manners to represent social actors inside the networks. One of Moreno's ideas of placing nodes in positions located in physical (geographical) space is used in this analysis (FREEMAN, 2000). One of the factors used to create groups, which defines the position of the actor within the network, results from the consideration of the geographical coordinates of the institutions Location.

Nevertheless, another innovation designed to extend Moreno's general approach began to be introduced by other researchers in ways to emphasise structural features of social networks visualisation. One structural feature that was of great interest to early researchers was the

[7] Jacob Levi Moreno (1989-1975)

sociometric status. The sociometric status of a node was defined as the number of choices, or the strength of the choices, received by that point. This index is one of the most innovative and uses indicators to measure the power and influence of a given one node within a network (BRANDES, 2003).

One classic example using the sociometric status index to visualise a network was produced by LUNDBERG and STEELE (1938). In this case, the nucleus of the network represents those actors with superior sociometric status. They constructed the image, designated as "Lady Bountiful" (Figure 6), as a representation of very well defined nucleus composed by the main actors that were placed in the middle of the drawing. The points representing the actors less chosen were positioned in circles around this nucleus.

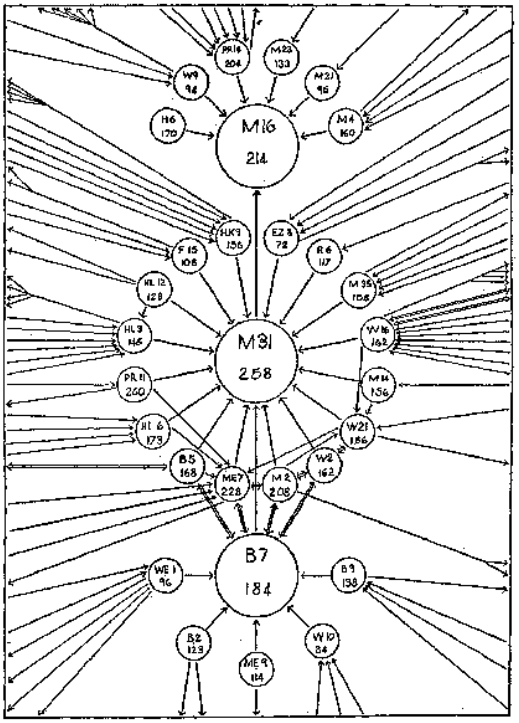

Figure 5 - The "Lady Bountiful" social network visualisation. Source: LUNDBERG and STEELE, 1938

This early imagery (rather improvised and made accordingly with the interests of each researcher) evolved to other types of images in which were applied standardised procedures for placing points in two, and in three-dimensional space (FREEMAN, 2000). A more recent trend is the use of combined multivariate statistical analysis (factorial analysis of principal components and of multiple correspondences; and hierarchical cluster analysis) as a base for sort arrangements to create images of networks.

This review of the social networks graphic analysis, points up a number of interesting possibilities to apply in the water resources management at local scale. Perhaps the most central issue is the clear indication that networks visualisation has a key role in network analysis research. Since the earliest studies, visualising networks have been used to identify structural perceptions and to communicate those understandings to others.

Using AGNA tools to analyse social networks

The analysis of networks based on images needs an essential decision about the specific software to use. Currently it is possible to find available plenty of free software with the appropriate characteristics to this type of analysis. The JAVA-based display programme AGNA is one of the possibilities, and was the software adopted in this study. Primary, it is necessary to

download the setup file and user manual to install on the PC. Once it is installed, and the JAVA software is running, AGNA will be automatically prepared to generate images to support the networks analysis.

AGNA was designed by Marius BENTA[8] for viewing and manipulating images of social networks, sociometry and sequential analysis. It is a very small program, but flexible and easy to use. It simply draws images and does not impose any restrictions based on the knowledge of some specific discipline. It requires input in a simple format or with a simple copy/paste from one database. With this tool is possible to create, edit, store, analyse and visualise social networks (BENTA, 2003).

The creator of an image can draw points and lines, use colour and present to the viewer any number of different networks. However, the viewer has options for reading and saving files and changing pictures. With the available scrollbars, the viewer (analyst) can control the zoom factor and the display of all characteristics that it possible to associate in the images.

With AGNA is possible to use some analytic tools to generate the following analyses (BENTA, 2003):

- General information (a basic description using some structural parameters: Diameter, Density, Cohesion);
- Information about the shortest paths in current network (Geodesic Matrix, Shortest Paths...);
- Some node-level coefficients (four types of centrality coefficients and a few sociometric coefficients) together with their network-level aggregates and/or statistical descriptions.

A simple network visual editor is provided with this tool. This viewer is based on a spreadsheet representing a relational matrix between the actors present within a given network. The resulting image can be saved in the hard disc of the computer or inserted into one output file document.

AGNA also allows customising network images (the type of task necessary when a sort arrangement is made: scale the image; set the network layer (random vs. circular); change the title attributes; specify the grid lines parameters; change node names; change background settings; develop another face settings for all nodes. Furthermore, some operations can be performed both in the Sociomatrix Editor and in the Network Viewer: adding new nodes, transposing network, and *symmetrising* the network. Apart from these tools, the Network Viewer lets you clone, delete or isolate the currently selected node (BENTA, 2003).

2.3 Local Network Data Analysis

The analysis of local network data generally follows a sequence of steps that aim at identifying typologies of actors and interactions. The first step involves two different types of analysis. One refers to the centrality analysis and the other to the entire network analysis. In the study of centrality, the aim is tie-level analysis, and all ties from all networks are analysed. In network-level analysis, summary measures of each network's composition can be calculated, e.g., the percent that give technical support; mean frequency of contacts, etc. (WELLMAN, 1992).

2.3.1 Centrality Analysis (individual perspective)

In this type of social network analysis, information about social actors, (their objectives regarding the main subject, their characteristics, as well as the content, direction and strength of interactions) must be stored and provide information about the complexity of the all network.

The centrality analysis is the most important way to identify the actors that play the most relevant roles within the network. One of the outputs of this analysis is the identification of the more prestigious stakeholders, which reflect the higher number of contacts.

[8] The AGNA Project was conceived and developed by Marius I. BENTA, from University College Cork (Ireland). E-mail: imbenta@yahoo.co.uk - URL: http://www.geocities.com/imbenta (AGNA Version 2.1.1 is currently available for download, released on December 12, 2003).

2.3.2 Entire Network Analysis

The entire network analytic procedures allow identifying the structure of each subdivision of the social network. However, this is arduous to do for large samples of individuals' perspective. For manageable samples, the resultant structural data can be merged (via SPSS) with the datasets describing each individual attributes and the composition of each centred network.

Entire network analysis examine the structure of social networks (including groups or clusters), as well as the networks' composition, functioning, and links to external situations. For example, with the questionnaire created to be the base of the analysis it is possible to examine questions such as:

- Who interacts with whom? (the composition of ties)
- About what? (the content of ties and relations; the composition of ties)
- Which type of relationships is used to accomplish the contact (a) to whom and (b) about what?
- How do ties and relationships are maintained, or changed, over time?
- How do interpersonal relations such as professional meetings, work role and organisational position affect the all of the social network?

To use the AGNA tool to analyse this relationships, data (acquired with the questionnaires) must be transformed into a matrix with rows and columns representing the units of analysis. In a stakeholder-by-stakeholder whole network study, the columns and rows represent the different actors interviewed. In a directed matrix, rows represent the initiators and columns the receivers of specific relations.

Each question is represented by one matrix. Individual matrices are created for separate groups. Managing data in matrix format can be a challenge if there are many different relationships or several types of media for each relation.

Entire networks can be described mathematically in a variety of ways. Departing from a visualisation of graph it is possible to create a set of ways to support the analysis of whole networks.

2.3.3 Identification of the Stakeholder Linkages

Analysing, from a social perspective, the problems regarding water management refers to the examination of stakeholders' organisation, their power relations and their prominence on the problem under study. However, power is a dimension difficult to define precisely and therefore to study. Therefore, two issues need to be considered before selecting the methods to use in the analysis of stakeholders linkages (ICRA[9]):

Stakeholders who contribute to the cause of the problem must also contribute to its solution. However, some may take certain elements as granted or are unable to voice their concerns. Stakeholders who have some control over water resources or generate most income from them may see the present situation as "natural". For cultural or political reasons, the weakest groups may not be in a position to articulate their complaints.

Participatory methods using group meetings create public discussions where power relations may play out unnoticed. They can thus serve as a vehicle for the most powerful stakeholders to advance their own interests by giving them legitimacy through an apparent group consensus.

Two principles must consequently guide the analysis of the links between social actors (ICRA):

The choice of methods should be appropriate to the type of information they want to generate. The use of several methods may be required to give a free and unfettered voice to all stakeholders.

The analysis must reflect group processes and interpret them. Nevertheless, they can only interpret the outcome of group processes if they have some previous knowledge about

[9] ICRA - International Centre for development oriented Research in Agriculture (http://www.icra-edu.org)

local/social differentiation and resource allocation. It is therefore important to use secondary sources of information.

After applying the social networks methodology, the following results would be achievable:

- Identification of the stakeholders relevant to some proposed development strategy;
- Identification of the main roles/functions, power, influence, and interrelationships among stakeholders that will be necessary to improve the proposed responses of the MULINO-DSS and the development strategies in general;
- Identification of potential sources of conflict among stakeholders to be involved in the solutions to the problem and possible mechanisms for conflict management.

2.3.4 Differentiating Groups of Stakeholders

Creation of stakeholders' types requires the use of specific criteria. These may be geographical, socio-economic or technical. It may sometimes be necessary to use different criteria, for example combine geographical location with socio-economic criteria. The resulting typology and the degree of detail of this will depend on the problem being addressed and the outputs expected.

An important decision is on the method of selecting criteria. This is an important issue since stakeholder differentiation is not simply used for targeting strategies but also as a tool of analysis. Adapted from the experience of the ICRA it is reasonable to consider that the involvement of stakeholders in this process of identification of criteria is very fruitful for the analysis.

The aim of the methodology adopted is an approach based on a structured analysis followed by factor and cluster analysis. However, other methods, more experimental, are also applied. They are based on the identification of different typologies departing from the visualisation of the clusters supported by the information collected with the questionnaires.

Thereby, the way of stakeholders' involvement in different problems regarding the water management, and their degree of participation is essential in the development of typologies. This is a delicate issue since stakeholders may not identify with the group they have been put into. In this process it is necessary to be aware that the results of the analysis could be critical and therefore may be important that the process be as dynamic and iterative as possible..

Defining Typologies

For the definition of typologies, two different methodologies could be adopted. Both approaches start with the same two steps (ICRA): 1. build hypotheses about the differences between groups of stakeholders 2. define the variables that can explain the differences hypothesised

Build hypotheses about the differences

In this first step, is necessary to create a set of hypotheses that can explain the differences of stakeholders' clusters in the catchment. For example: what are the factors that explain the different stakeholders needs of water? What are the factors that explain the degree of participation of stakeholders in the decision-making processes?

Define the variables

The next step is to define the variables that can be used to test the hypotheses developed. These variables will be the criteria for the typology. For example, a hypothesis might be that the quantity of water available is a major determinant of the differences in water uses. The variable that can be evaluated to test this hypothesis might be "water in reservoir available last years" or "number of days with lack of water resource in the last years". After this step, the two approaches use different methods to test the hypotheses:

Focused Sampling

- Make a provisional typology, based on the objectives of the study and a matrix of the selected variables (resulting from the interviews).
- Interview a few stakeholders by water use type, or verify the interim typology by collective interviews.
- Revise the typology, and re-verify, until the results are suitable

Multivariate Analysis

Collect quantitative information, using secondary information or stakeholders surveys. Typical variables for quantification include: level of decision making, level of technology used, alternatives water supply, etc.

Analyse the data. If only variables have been measured, simple cross-tabulation can be used. Otherwise, the factorial analysis must be used to select those variables that account for most of the overall variation within the sample.

The types of stakeholders resulting from the cluster analysis, or the types identified, could be faced with the interim results to verify the usefulness of the typology developed for the purposes of the local networks analysis.

As can be seen from the above, the two methods are similar in the process of verifying the hypotheses. The different steps of data collection are what distinguish these approaches. The method using purposeful and iterative sampling is more flexible and most probably faster in most circumstances. However, it is more subjective then the multivariate analysis, which gives a more quantitative results (usually more convincing to policy makers). However, this method is harder in terms of data collection (a larger number of stakeholders is required for a statistically valid data), and more demanding in terms of knowledge regarding the statistical background of the researchers (ESPOSITO, 2002).

The creation of clusters or groups based on a variable, as an example of stakeholders' purposes, can help to identify statistical influences in more directly network indicators.

3 ANALYSIS OF LOCAL NETWORKS

After considering the theoretical concepts introduced in the previous chapters, the next section will present the overall background of the local networks of the different European studied areas and will discuss some aspects related with the Caia's local network, which was identified in the Portuguese study area of the MULINO project. It will be also stressed the links with the MULINO-DSS. In this sense, it considers the effects of different structures on the identity of the network. To do this, the key point of the work was the creation of a system that would expose the structure of the local network.

The analysis of Caia's local network is based on the study of stakeholders that could have some type of influence on the decision-making process concerning the water management at the local (river basin) level. The two objectives of the analysis are: First, to determine if there are any groups of individual agents whose patterns of interactions are sufficiently similar to be considered as a type of stakeholders; Second, to describe the patterns of interactions among stakeholders (typifying the water management process), and to identify their roles on the network.

Other kinds of answers could also be found, i.e., is there a specific structure of interaction among stakeholders, or do stakeholders interact arbitrarily with each other? Is there any stakeholder or group of actors that play such an important role in the networks that the networks structure will be destroyed without it (them)? Although the importance of individual interactions, the research is also oriented to search for group structures within the community.

The analysis of Caia's local network is organized according to a set of research questions as follows: What stakeholders were considered? What questions were asked, and, what information was collected? How was the data organised? After the approach to these questions, is presented the multi-dimensional analysis of data collected in Caia's catchment.

3.1 Data Collected

In the local network of Caia River catchment were identified, in a first phase, a set of 14 stakeholders. This number of actors was considered suitable for the dimensions and socio-economic characteristics of the catchment. The support of the end-users (INAG and IHDRA) was fundamental to the selection of the stakeholders to be interviewed. These interviews aimed at understanding the type of interactions among the stakeholders, their relationships with the end-users, and to identify the main problems related with water management in the catchment. After the initial interviews was necessary to append more four stakeholders. In Figure 7 is possible to see the location of the complete list of stakeholders.

- **National** (Lisbon - end users): INAG; IDHRA;
- **Regional (Évora and Portalegre)** : DRAOT; DRA;
- **Local (Elvas, Arronches, Campo Maior and Portalegre)**: Caia Irrigation Board (ABC); Olive Oil Producers; Cereals Producers Association; Tomato Producers Association; Beetroot Producers; Farmers Association (Agroraiana); ESA (Agrarian School); Arronches municipality; Campo Maior municipality; GEDA (environmental ONG); Portalegre Municipality, North Alentejo Municipalities Association.

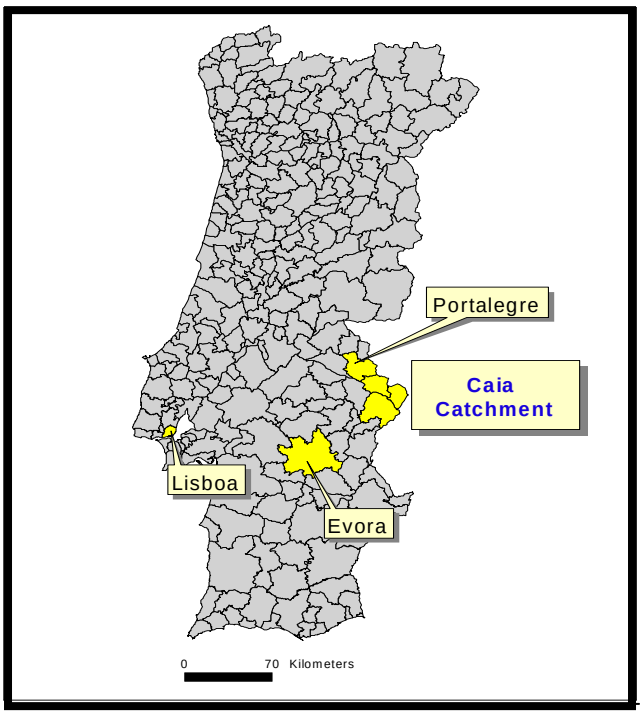

Figure 6 – Location of 18 stakeholders of Caia Social Network in a multi-level analysis

3.1.1 Objectives of the questionnaire

The main objectives of the questionnaire are the follows:

I Identification of the stakeholders objectives and responsibilities according the use, and management, of water resources in the catchment.

II Review of the stakeholders' means of intervention to accomplish their objectives.

III Identification of the state of water resources and the main management problems

IV Identification of response actions and means of intervention for the resolution of the problems

V Description of the institutional framework

3.1.2 Structure of the questionnaire

The questionnaire was developed in ten main topics, which could be summarised in the following subjects:

- Identification of the stakeholders' objectives and responsibilities for the use and management of water resources
- Review of the stakeholders' means of intervention to accomplish their objectives Water availability
- Identification of the state of water resources and the main management problems
- Identification of response actions and means of intervention for the resolution of the problems
- Conflicts related with water uses
- Description of the institutional framework
- Water price
- Support to optimise water resource management
- Information
- Local network intensity

3.1.3 General background of the local networks in the five case-study areas

With this set of questions was possible to make an analysis of the overall background of the local networks. In general terms, there were very few situations where no answer was provided. Consequently, the absence of answer does not hinder a comparative reading of the data, as these questions are either very specific or refer to isolated situations and therefore do not represent an obstacle to the conduction of this comparative analysis.

On the other hand, the analysis has been more conditioned by the differences noticed in terms of the way the answers have been structured. In two case-studies, a direct answer was given to the questions (Italia, Romania); in the remaining study areas, (Belgique, Portugal, and United Kingdom), a more expanded answer was given to some questions.

Water resources policies and management

The objective underlying this item is to identify the formal differences concerning national water resources management policies. Based upon the more or less centralising, participated and displaced (in terms of definition) orientations, it is possible to establish a standard regarding the water resources management policies at the level of the countries involved in the MULINO project. We have furthermore tried to understand how the institutions responsible for the management of water resources act in each of the countries analysed, and to what level and extent they intervene.

National and regional levels of water management

One of the most noteworthy standards in terms of national policies regarding water resources is the tendency for decentralisation in some countries. In Italia, and above all, in Belgique (Table 2), this tendency is so remarkable that it contributes to the difficulties sensed in terms of naming a national entity responsible for water resources management. In these cases, it is possible that the determination of national policies has its origin in the framework of inter-regional co-operation, as a collection of interests based on a common principle – the defence of the water resources of each district.

Although it relates directly to these institutions, (Table 1) the manner in which national policies are to be implemented has been defined in accordance with some supra-national impositions such as the WFD.

Belgique	The management of Belgian water resources is very fragmented with lots of subdivisions. The *Direction Générale des Ressources Naturelles et de l'Environnement* of the Wallonian Region Ministry is in charge of the co-ordination and implementation of water resource management plans in the region
Italia	Since the 70's there has been a process of division of powers at the local level and of decentralisation of decision making related to water resources management: from State to the regional and even provincial or municipal level.
Portugal	Ministry of Environment and Territory Management through the Water Institute
Romania	Ministry of Environment and Waters
United Kingdom	Environment Agency

Table 1 – The water resource management policy at national level

The impulse given by EU directives for the definition of national policies regarding water resources has an increasing significance. The internal organic of each country will determine a differentiated phasing for the transformation process of the mentioned directives into national laws. After the definition of these national policies, we can proceed to its application by means of plans with a variable time span.

In Italia, since the 70's there has been a process of division of powers at local level and of decentralisation of decision making related to water resources management: from State to the regional and even provincial or municipal level. Usually, the first impulse is given by the European directives, which are then subject to the parliamentary process that makes the ordinary laws. The environmentalist pressure groups and forces from the production system could also influence the water national policies. The lobbying exerted by these social forces, especially in the case of economical agents, tend to delay the implementation of environmental

legislation. In this country the main institutions for the management of water resources are the Ministry for the Environment, the Ministry for Public Works, the Ministry of Health, the Ministry for Community Policy Co-ordination and the National Environment Agency. The responsible for the regional level of management are the Regional River Basin Authorities and the Regional Environment Agency

In the case of Belgique, the regional level determines the connection between EU directives and the implementation of plans. The main point is that the management of Belgian water resources is very fragmented, with a lot of subdivisions and the institutions responsible for water management are different for each Belgian region. The degree of participation of other entities in the making of national laws is particularly relevant in this country with a very high level of decentralisation of issues regarding water resources. In Belgique, some research centres design plans that will, in turn, influence national policies concerning water resources.

The national level of the water resources management in Belgique is segmented in some sub-themes. Maintenance of navigable streams is the concern of the Ministry of Environment and Transport (MET). Furthermore, all trans-boundary navigable waters are the concern of the Federal Government (Belgium National level). To co-ordinate the management and implement the public engineering, a public society of water management (SPGE, *Société Publique de Gestion de l'Eau*) has been created in 1999 (by Decree M.B. 22.06.1999), particularly taking care of the sewage treatment (wastewater plants management and in general the cycle of waters going through pipes) and protecting the quality of both surface and ground water resources. The SPGE is here to help to collect funds to recover the backwardness in the different water uses. At the moment, there are no complete private institutions that manage water resource in the Wallonian Region but this situation is planned to change.

In Belgique the *Direction Générale des Ressources Naturelles et de l'Environnement* of the Wallonian Region Ministry (DGRNE) has a water division (Division de l'Eau), which is in charge of the implementation co-ordination of the water resource management plans in Wallonia, for both surface and groundwater. This division is composed of 8 directions, each being responsible for one specific aspect of water resources within the water cycle. The main objective is the quality concerns of both surface and ground waters.

In the United Kingdom, the Environment Agency has the authority for the management of water resources in England and Wales at all levels. It has the responsibility for: long-term resources planning; flood defence on main rivers; water quality; waste minimisation; fisheries; and navigation in some rivers. This agency is also responsible for the management of water resources for each catchment through the Catchment Abstraction Management Strategies, Local Environment Agency Plans, drought plans and a review of water company water resources plans and drought plans.

In Romania there is a five years plan for water resource management at the country level, approved by the Central Government. Using this medium time plan, a yearly plan for water management in each catchment (Master plan) is approved by the Romanian Water Company, and then by the Ministry of Environment and Waters. The Romanian Water Company is responsible for the national level of the water management in this country and its regional branches are responsible for the regional water management.

In Portugal the process of planning and management of water resources is regulated by decree law Nr. 45/94 of February 22nd. In accordance with the mentioned decree law, fifteen river basin districts were established, approximately coincident with the main river basins. Nevertheless, the management entities of each river basin district (the Catchment Councils) have only advisory functions in terms of regional planning and are composed of elements from the central and local administration. According to decree law Nr. 45/94 also established the need to create a catchment plan (PBH)[10] for each river basin district, as well as a National Water Plan (PNA),

[10] In accordance with the mentioned document, the Water Institute (INAG) is responsible for the creation of the PNA (Water national Plan) and PBH (Catchment Plans) for the rivers Minho, Douro, Tejo/Tagus and Guadiana, while the Regional Directorates of the Environment and Territory Ordnance (DRAOT) are responsible for the creation of the PBH for the remaining rivers. The reason for this division results from the fact that the catchment which fall under the direct responsibility of the INAG either include regions outside Portuguese territory or refer to river basins which include more than one DRAOT.

which is the fundamental instrument for the definition of the management policy for water resources[11] in Portugal. The management of water resources is structured in the following levels (decree-law n.º70/90 of March 2nd.):

At central level: co-ordination functions at national level, international representation and promotion of major goals or nation-wide initiatives;

At river basin or river basin district level: public domain water authorities, namely those responsible for licensing and fiscalization, as well as for promoting and supporting hydraulic development based upon an integrated planning process which identifies available resources, needs, "throttling" situations and potentialities, as well as short, medium and long term goals, together with the necessary resources and actions for their attainment;

At sub-regional or local level: users of water resources from the public hydric domain prevail at this level; they promote and carry out actions aiming at hydraulic development, including the creation and exploration of hydraulic infrastructures.

The Institute of the Water (INAG) is an organism of the Central Government, in the dependence of the Ministry of the Environment and Ordnance of the Territory, and has the responsibility of execution of the national policy in the domain of water resources and of elaboration of the National Plan for the Water, which at this moment is in the final phase.

In Portugal the regional level of administration does not exist[12]. At regional level it is possible to see only the decentralisation of the central government services and ministries. The Regional Directorate of the Environment and Territory Ordnance, the Regional Directorate of Agriculture and the Commission for the Regional Co-ordination of Alentejo are examples of these institutions, which exert functions of authority in the hydrologic public domain, without actual powers of decision-making.

From the set of answers collected, a number of ideas stands out which should be considered once again:

At national level, the management of water resources is carried out by institutions with very different characteristics in the context of this project. In the United Kingdom, for example, there is one single entity (Environment Agency) with large influence from the national to the local level, while in Belgique, due to specific institutional reasons, the management of water resources is extremely fragmented.

Apparently, *stakeholders* do not have much powers of intervention in the process of determining national policies for the water sector. This factor allows us to stress the need for the creation of local networks with powers to exert their influence in the defence of the interests of each basin in terms of defining national policies for the management of water resources.

Local level of water management

The importance of the local level of water management is particularly significant in terms of understanding the case studies of this project, as it corresponds to a number of institutions which are involved in the management and utilisation of water resources and which have the capacity to act directly upon the water sub-systems under analysis. These institutions, which have management powers at local level, present themselves as potential elements of the future local networks.

In Italia, the District Authority, the Municipalities, the Land Reclamation Districts, the Civil Engineers and the Consortium are the authorities responsible for the water management at local level. These are also the institutions responsible for the water management in the catchments of the case study areas.

In Belgique, at local scale, the water resource management is usually the concern of the grouping force of communes (*compagnies intercommunales*). In the Dyle catchment, it is *l'Intercommunale du Brabant Wallon* (IEBW). Of course, it follows the management plans execution ways delivered by the SPGE.

[11] One of the most significant goals of this National Water Plan is to draw up a list of solutions for the problems that concern the water deficit affecting some Portuguese water basins.

[12] In 1998, the population in a referendum refused the implementation of administrative regions.

The drinking water companies are very efficient in monitoring the aquifers that they exploit, what explains why the SPGE does not tackle the management of groundwater. Thus, to simplify the situation, we can say that:

SPGE (*Société Publique de Gestion de l'Eau*) is responsible for the treatment of waste surface waters,

SWDE (*Société Wallonne de Gestion de l'Eau*) is responsible for the drinking groundwater.

The UK local management water level at the area of study, the Environment Agency, has a role of consultant and provides advice on projects that could affect water resources or flood protection.

The Internal Drainage Boards are in charge of providing land drainage and they have been described as "virtually autonomous co-operatives of farmers and landowners who have a strong interest in ensuring that drainage work continues" (E.C. Penning-Roswell, D.J. Parker and D.M. Harding, Floods and Drainage: British policies for hazard reduction, agricultural improvement and wetland conservation, Risks and Hazards). They have special concern in the lowland marshes.

In Romania there are the Catchment Committees. In the area of study, Catchment Committee of river PRUT.

The sub-regional or local level in Portugal, where the users of water resources of the hydric public domain prevail, promotes and carries out actions of hydraulic engineering, including their accomplishment and operation. In the management of water resources of the State, the following entities intervene: municipalities, associations of users and individual users.

To conclude this section, it is important to refer that it is sometimes difficult to accomplish the analysis of these institutions from different levels of management of water resources as it is not possible to frame all countries according to the same models of geographic fragmentation of the decision-making powers.

As a significant part of the institutions presented will participate in the MULINO project it is important to determine in general terms at what level their collaboration will take place: the entities operating at national and regional level will benefit more directly from MULINO DSS, as the end users have powers of decision at these levels. Entities operating at local level will be integrated in local networks as stakeholders.

Uses of water resources in the catchment

One of the fundamental issues regarding the MULINO project resides in understanding how water use is influenced by the management of water resources in each river basin selected as a case study. This last type of issues also includes a general and comparative characterisation of different ways of water uses, as well as the possible land use changes in the years to come. The conflict of interests regarding water use is one of the most important aspects for understanding/evaluating the way this resource is managed at the catchment level.

One of the interesting aspects regarding the use of water resources in each catchment studied in the MULINO project is the difference between the case studies of Italia, Romania and Portugal, on the one hand, and Belgique and United Kingdom, on the other hand.

In fact, regarding the case studies of the South of Europe, a predominance of agricultural water use can be noticed. The importance of the industrial sector in Portugal should be stressed (more than 10% of the total), thus reflecting the importance of this sector in the group of municipalities analysed. Italia is the only case study in which the figures for water consumption regarding the sector of tourism were presented. Although it now represents only 2% of the total, water consumption in this sector might be responsible for the most significant growth in terms of water use during the next years.

In the case studies of Belgique and United Kingdom, domestic consumption prevail over the remaining water uses. Nevertheless, there is a bigger diversity in terms of demand of this natural resource. This fact is more evident in the case study of the United Kingdom, where agriculture is responsible for approximately 20% of the water consumption and industry over 10%. In the case study of Belgique, water use in mines and quarries is of great importance (7% of total consumption). This fact largely contributes for the singularity of this example, as it is the only reference to this type of water use in all the examples analysed.

Consequently, we can assume there is a certain dichotomy between the two groups of case studies: on the one hand, the South of Europe with essentially agricultural water use, and on the other hand, the Central /Northern Europe, where domestic supply prevails significantly. This fact naturally reflects the different needs of agricultural production systems in terms of watering. On the one hand, we have Italia, Romania and Portugal, where rain is very irregular and concentrates in certain months, thus causing water deficit periods. In these countries, watering is used as a fundamental factor for agricultural production; without it, cultures do not have many possibilities for vegetative development. On the other hand, due to the regularity of precipitation all year long in Belgique and United Kingdom, watering becomes a form of supplement and a way of ensuring better and regular agricultural production.

The case study of Romania is characterised by larger diversity in terms of water use. However, the agricultural sector represents almost half of the total water consumption, while the remaining half is shared between the domestic and the industrial consumption. Industrial water use in Romania (23%) is the most relevant of the five cases under analysis.

Conflicts between the various uses of water

There are no well defined patterns for determining conflicts among the various water uses over Europe. Although it was possible to establish regional similarity in terms of water use, greater differences seems to exist in terms of conflicts. One of the aspects which is more common to the examples under analysis is the conflict of interests between water use for agricultural purposes and water use for domestic purposes. Problems concerning pollution are likewise pointed as sources of conflicts, although the underlying causes differ among the different countries.

In the two case studies of Italia the main conflict is between neighbouring areas that use water from the same water body, and different sectors such as agriculture and fish farming.

In the Dyle catchment, the case study of Belgique, the agriculture is usually the main activity accused of nitrate and pesticide pollution of groundwater used for drinking water production. However, the main vocation of surface water is to receive waste waters, particularly domestic effluents (industries are less well represented). Moreover, unlike groundwater, surface water engages the local population because the pollution of surface water creates unpleasant smells that causes a reaction by the public. Fishing and environmental associations are very dynamic in highlighting the pollution problems of surface waters. They defend the protection of the Natural Heritage (*Patrimoine naturel*). In reality, everybody (stakeholders and end-users) wants rivers to be purified, what is not a conflict in itself, but wastewater treatment plants have to be installed.

In the United Kingdom there are several sources of concerns and issues in the Bure and Yare river catchments:

The stakeholders would like the abstractions to remain the same in the future as they are now, or if not, to have secure amounts of water allocated to abstraction.

The impact of abstraction for public water supply and irrigation on habitat is seen as an issue.

Finally, the effect of low flow on wetland habitats is regarded as a concern as well as the availability of water for abstraction during low flow periods.

In Romania, in the Bahlui river basin, it is fundamentally a matter of competition between water use for agricultural purposes and for domestic purposes. There is a lot of pressure in the sense of using more water in agriculture in detriment of domestic consumption.

In Portugal, in the basin of river Caia, most conflicts fundamentally arise during periods of low rainfall what makes it necessary to take measures in order to safeguard reserves for domestic consumption and to respect the ecological flow of Guadiana river, in detriment of agricultural use.

On the other hand, focuses of diffuse pollution result from spilling and infiltration of waters from soils with an intense agricultural activity. Some shortcomings can also be noticed in the treatment systems for urban and industrial wastewater. Therefore, we can say that also in the Portuguese case water quality is one of the sources of conflict between the users of water for agricultural and for domestic/industrial consumption.

Due to the geographic situation of the catchment under analysis, the trans-boundary question is particularly relevant in the Portuguese case study. Consequently, we realise that there is a conflict related to the usage of water by Spanish farmers, who in periods of shortage are greatly responsible for the near inexistence of flow in Guadiana river.

Another type of conflict is caused by the proximity to Spain and concerns the pressure exerted by the population from the nearest Spanish urban area, Badajoz. The growing number of people crossing the border to enjoy the tourism and leisure activities in the area surrounding Albufeira do Caia is contributing to increase the levels of pollution in these waters. So far, there is still a lack of adequate regulation concerning the increasing number of visitors, thus leaving free ground for the occurrence of conflicts between the responsible entity for the ordnance of the dam (INAG), the municipalities (which are responsible for the treatment and distribution of water for domestic consumption) and the ASSOCIAÇÃO DE BENEFICIÁRIOS DO CAIA (Caia Irrigation Board), which is responsible for the distribution of all the water from the dam.

Institutions and catchment plans in the case studies area

In this section, we intend to evaluate the differences between the institutions with decision-making capacity of each study case. In order to a better understanding of this matter, a comparative analysis has been the conducted on some institutions in particular (as was the case with the catchment councils and the stakeholders associations), as well as on the major catchment ordnance plans.

In each country, there is a large number of institutions with capacity of intervention on the level of the catchments used as case studies (Table 2). These institutions are partly the end users and the stakeholders who are expected to play a fundamental role in the constitution of local networks.

Country	Institution
Italia	Land Reclamation Districts "*Destra Piave*" and "*Basso Piave*" Regional Authority, Regional Basin Authorities, Regional Environment Agency, Association of Agricultural Producers District Authority, Municipality
Belgique	Dyle catchment council The co-ordinator of the cell «planning and measures» of the Division of water at the DGRNE that is also participating in PPGIE (*Plate-forme permanente pour la gestion intégrée de l'eau du programme PIRENE*)
United Kingdom	The Broads Authority has got the responsibility for the largest protected wetland in England. The Anglian Water supply company.
Romania	Romanian Water Company Catchment Committee Local Authority for Risk Prevention
Portugal	Municipalities, Municipality Association; "Associação de Beneficiários do Caia" (Caia Irrigation Board); INAG, IHERA

Table 2 – The institutions with decision-making capacity that intervene in the catchment

In what concerns the institutions with decision-making capacity on the catchments used as case studies, some common aspects can be found. The institutions with decision-making capacity at municipal level are responsible for drawing up the ordnance and management plans, as well as for their application. The mentioned municipal ordnance plans shall take into account the hydrologic issues, which are incorporated in a global management strategy for natural resources. In some cases, we can observe that their powers do not go beyond the level of presenting proposals for changes in already existing sector-based plans at other levels of action.

In three of the five MULINO Project countries, there are references to institutions with capacities at regional level. These institutions, which hold decision-making capacities at this level, mainly

present co-ordinating characteristics. However, there are very obvious examples of institutions at regional level with sector-based, agricultural, environmental or territorial ordnance competence, which have decision-making powers over water resources. This situation essentially arises in cases where water basin districts have not been established, thus leaving decision-making capacities regarding this issue to other regional entities with more embracing and wider sector-based competence.

Decision-making at regional level is also associated with water basin districts themselves, defined in accordance with the respective catchments. In the cases where this entity exists, its decision-making capacities regarding the management of water resources may supersede the remaining decision-making organs.

Regardless of whether water basin districts have been established or not in these case studies, the importance of water management at regional level is recognised. Proof of this is the fact that all countries make reference to this level of management. The same cannot be said of the national level of decision-making.

The national level of management of water resources is not a common feature to all countries. The two omissions at this level of decision-making are: Belgique, a country which opted for defining the territory ordnance at regional level in such a complete manner that the definition of a national policy for this sector becomes very difficult; the other example is Italia, where no reference is made to the decision-making capacity of the central authorities as a result of the decentralisation process started in the seventies which delegated power into regional and municipal entities.

In what concerns Italia, it is important to mention that the financing issue is considered the most relevant competence assigned to the institutions related to water management. The major differences arise between the entities operating at local level which present projects needing financial support and the entities operating at regional level which have capacity to decide upon their approval.

In the case of Portugal, there are still two organisms which hold decision-making powers over matters concerning management of trans-boundary water resources with impact on the case study. The goal is the existence of a regulation, the “Luso-Spanish Convention” for river basins. The Commission in charge of this task is the main organ for solving matters regarding the protection of waters and of aquatic and terrestrial ecosystems which depend upon them. This Commission also holds powers to alter the contents of the Convention, namely by changing the limits established in terms of the flow rates.

Catchment councils

The existence of catchment councils relates to the creation or approval of catchment ordnance plans. This is the most relevant information resulting from the analysis of the MULINO Project case studies (Table 3). The absence of Catchment Councils is particularly significant in the case studies of Italia, as it is a country with a high level of decentralisation of powers regarding the management of water resources.

In the case of the UK, although Catchment Councils are inexistent, there are nevertheless mechanisms designed for consulting local entities and the stakeholders themselves, which operate practically in the same manner as a Catchment Council.

The existence of an organism with the characteristics of the Catchment Councils is very important for the development of the MULINO Project, as it allows the detection of possible ways in which different entities with a common interest for the management of water resources can relate.

Country	Catchment Council	Functions	The participants
Belgique	Yes	To make an assessment of the To plan concerted and integrated actions	Both end-users and stakeholders who agree to sign the contract of the integrated actions.
England	No, but…	The Environment Agency drives consultation through the Local Environment Agency Plans (LEAPs) and the Catchment Abstraction Management Strategy (CAMS); To manage the air, land and water environment at a local level.	The LEAPs participants: The direct partners: local authorities, big industries, water companies; The participating groups: conservation, recreation, community groups; Other agencies: emergency services, highway The CAMS to consult stakeholders
Italia	No	-	-
Portugal	Yes	Monitoring the River Catchment Plan; To advance objectives to the water quality in the River catchment; To advance hydrologic studies to the catchment basin; It gives an advice on hydraulic exploitation works; It gives an advice on all issues related to the partition of waters and to the measures to be taken against pollution.	1 Water Institute DRAAL (Direcção Geral de Agricultura do Alentejo) Secretary – Co-ordinator of the Planning Unit (Water Institute) 16 representatives of the national government organisations related water use 16 representatives of the stakeholders (8 municipalities, ASSOCIAÇÃO DE BENEFICIÁRIOS DO CAIA) 2 environmental NGO's
Romania	Yes	Analysing and approving the master-plan which is then transmitted for approval to the Romanian Water Company	3 representatives of the users; 1 representative of the NGOs; 3 leaders of the local communities (generally mayors of the most important localities in the catchment);

Table 3 – The Catchment Council

Stakeholders associations

The importance of stakeholders is fundamental for understanding the reality of the target areas of the case studies. In many cases, the stakeholders are entities which have the powers to intervene in matters directly or indirectly related to water resources. The stakeholders associations can further extend their capacity of intervention over water resources. We recall the Portuguese example, in which a stakeholders association (Associação de Beneficiários do Caia – "Caia Irrigation Board") is the main responsible for the distribution of water resources in the study area. Although it was unthinkable for a stakeholder (farmer) to hold that capacity of intervention over water resources, the fact of joining in associations to fulfil that purpose has allowed them to best defend their interests.

It becomes of the utmost importance to identify and understand the action of the stakeholders as the co-operation of these entities is needed in order to establish local networks. In this sense, the existence of stakeholders associations may render a decisive contribution for the

creation of local networks, as they simultaneously represent different stakeholders, which makes them privileged means for the transmission of information.

All the study cases of MULINO project present stakeholders associations, although some of them operate only at local and regional level and some at national level.

In Italia there are both agricultural and industrial associations of producers with the purpose of getting financial support.

In Belgique the associations in the Dyle case study are participating in the catchment council. These are presented above. The objectives are to defend their own interests with a common point: the preservation of (surface) waters and their uses.

In the UK the main actors in the area are the RSPB, the Norfolk Naturalist Trust, the English Nature, the County Landowner's Association and the National Farmers Union. The RSPB and the Norfolk Naturalist Trust are two charities that have for main task the management of nature reserves and the English Nature is the statutory body for nature conservation in England. In addition to the management of nature reserves, it provides advice to the government for the implementation of policies and to other bodies. The County Landowner's Association and the National Farmers Union have different objectives from the other associations. They represent and promote the interests of farmers and landowners, and do not limit their action to environmental questions.

In the United Kingdom, preservation of nature is one of the fundamental concerns of the stakeholders associations. In addition to the management of natural reserves they provide advice to the government for the implementation of policies and to other bodies.

The Romanian Water Association, where end-users for drinkable water are grouped, synthesises the opinions and proposals of local end-users of drinkable water to Catchment Committees and to the Romanian Water Company PROPACT – Organisation of farmers using water for irrigation.

In Portugal, in the Caia river basin, there are different producers and municipalities associations which intend to co-ordinate common projects in order to increase resources profitability, benefiting from scale economies and from the know-how of the existing consultant services in each area of expertise. However, the most important one is the Associação de Beneficários do Caia (Caia Irrigation Board). It is this association's responsibility to distribute (manage) the water from the Caia dam among the associated farmers, as well as to proceed to the maintenance and modernisation of the distribution network.

One of the goals of the stakeholders associations is to make the interface between the concerns of water users and the end users. In some cases, they also raise synergies in order to obtain financial support for the productive activities they represent. In general terms, we are talking about farmers associations or municipalities associations which are responsible for the supply and treatment of water for domestic consumption.

National specificness assumes a greater importance in the Portuguese case due to the existence of a privileged stakeholder with very relevant features for this project - the Associação de Beneficiários do Caia (Caia Irrigation Board), a farmer association whose purpose is to create the necessary conditions for the distribution of water among its associates.

From the institutional point of view, the local level of analysis is marked by the existence of entities with capacity to operate at regional level and direct influence over the catchments that are the base of our case studies. Nevertheless, after having analysed the catchment councils, we realised that although this is a regional level organism, not all countries have chosen this line of action. This means that the level of regional management has a remarkable influence in all case studies, although the institutions or lines of action may differ from country to country.

The existence of a planning device for water resources at regional level in all the countries involved in the MULINO project reinforces the idea that the level of regional management is very influential at local level.

Despite the importance of the regional level of operation, largely as a consequence of the WFD – as in some cases resource management at this level was traditionally inexistent – the local level of operation still bears great relevance. In some countries, municipalities effect the control

within their administrative limits. In other countries, there are local entities with exclusive competence on matters regarding water resources.

The activity of both stakeholders and stakeholders associations in the defence of their interests regarding water resources essentially reflects upon the level of the sub-basins used as basis for the MULINO project study cases. This feature is common to all countries. In some cases, we verify that the influence and range of action of some stakeholders associations visibly allow them to have a more direct action upon the management process of water resources at local level.

Concluding remarks

Some fundamental questions regarding the implementation of local networks may relate to the specific situation of each region or even of each country. As a starting point, we dealt with four countries, members of the EU and one which isn't. This situation may have some influence upon the existing differences in terms of policies and decision-making processes. Nevertheless, there is an obvious attempt to comply with the EU standards regarding water resources on behalf of Romania, partly due to the adhesion process.

Although no dichotomies can be noticed resulting from the level of integration in the EU, the same cannot be said about the geographic situation. The two Southern European countries bear mutual resemblance in terms of water use but differ from the two EU countries from Central and Northern Europe. Therefore, we can assume that the creation of local networks inevitably implies analysing differences in terms of water use, which, in turn, reflect all the policies applied to this sector so far, as well as the biophysical features of each region.

The existence of catchment councils, although at regional level, may contribute to design a model of relationship among local entities, as well as among regional entities or even national ones. Based upon the experience of the case studies (included in more comprehensive catchment councils) it is possible to detect connections at the regional level among the different entities present in the areas of catchment under study.

The degree of decentralisation in terms of management of water resources may allow a better flow of information between end users and the stakeholders. In this perspective, large differences could be seen among the five MULINO countries, ranging from the Belgian situation, which corresponds to a high level of decentralisation, to the Portuguese case, where river basin districts have yet to be created. Despite the apparent limitations inherent to the more centralised situations, it should be said that it is possible to set other types of mechanisms in motion in order to create the necessary involvement among the stakeholders to lead to the implementation of local networks.

3.1.4 Data input for analysing the social network

The administration of the questionnaire (during July and September 2002) was crucial to supply the data necessary to the analysis of the local network structure. After the end of the rounds of interviews, the data arising from the questionnaire was treated and organised in matrices to be analysed with multivariate statistical analysis procedures. Therefore, the answers (both to close-ended and open-ended questions) were codified and a set of binary tables was built to be examined by factorial analysis.

In this process, typified matrixes were built. These matrices contain the variables names, the question, and the description of the variable name with answers types. Data entry was also carried out using the ANDAD software (Portuguese Software developed by the Instituto Superior Técnico). This program is suitable for this purpose because it is user-friendly and tests the entered data for its validity. Furthermore, it is a powerful tool for the descriptive analysis. Moreover, with this program is easy to export the data files into programs such as Excel or SPSS so that the possibility exists for switching to other computer packages later on.

A plausibility check must be carried out immediately after data input in order to correct erroneous data. Despite meticulous preparation of data, erroneous data always appears in the database. If unexplainable data entries are identified, these must be checked with the entries on the questionnaires. Erroneous data in the database should then be replaced by correct data obtained from the questionnaires. If no satisfactory explanation for a value can be derived from

the information in the questionnaires, either additional information must be obtained from the stakeholders, or the information must be excluded.

After the procedure of selecting data sets it is possible to start the statistical cluster analysis. The main goal is looking for groups of actors that are similar in characteristics due to previous selected determinants. For example, objectives of the institutions have characteristics that differentiate each organisation.

When clusters are to be created, it is important to be careful to ensure that there is sufficient variation and that the number of individual cases in each group is approximately the same. The classification techniques were made through the use of various clustering strategies such as aggregation method of *average distance*, and distance method of k². The main characteristics of each group are described in the Cluster Analysis Result Dendogram.

3.1.5 Analysis Design

The procedures to obtain the final grouping of stakeholders, in order to apply some advanced visualization methods, were structured in a great number of steps (Figure 8). The design of these procedures shows the importance of the statistical approach to apply this methodology.

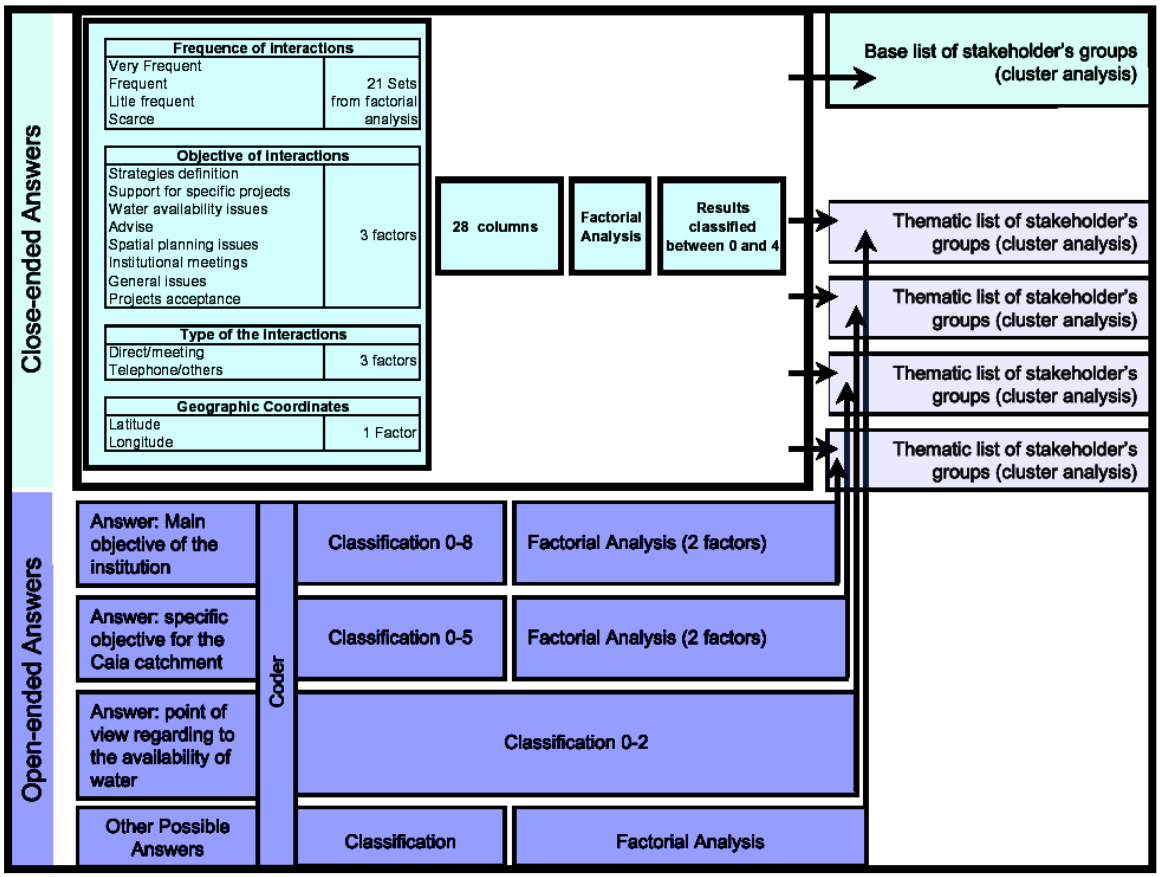

Figure 7 - Analysis design to obtain groups of stakeholders

The first run of statistical tools to obtain the basic list of stakeholders was created by handling just the close-ended questions. This first approach is very important to achieve the final results because this will be the subject of the first analytic approach (perhaps the more objective, because it is based on the more objective data) and this will be also a support to the next, more advanced, steps.

Another step of this analysis is established by the analysis of open-ended answers. After initial accuracy tests, the results of the treatment phase will be a number of significant factors to connect with the close-ended questions in order to run another time the clustering tools with data of open-ended and close-ended answers. The result will be a subjected list of stakeholders

groups created to support the analysis of the local network and also to support the arrangement of the network visualization (Figure 9).

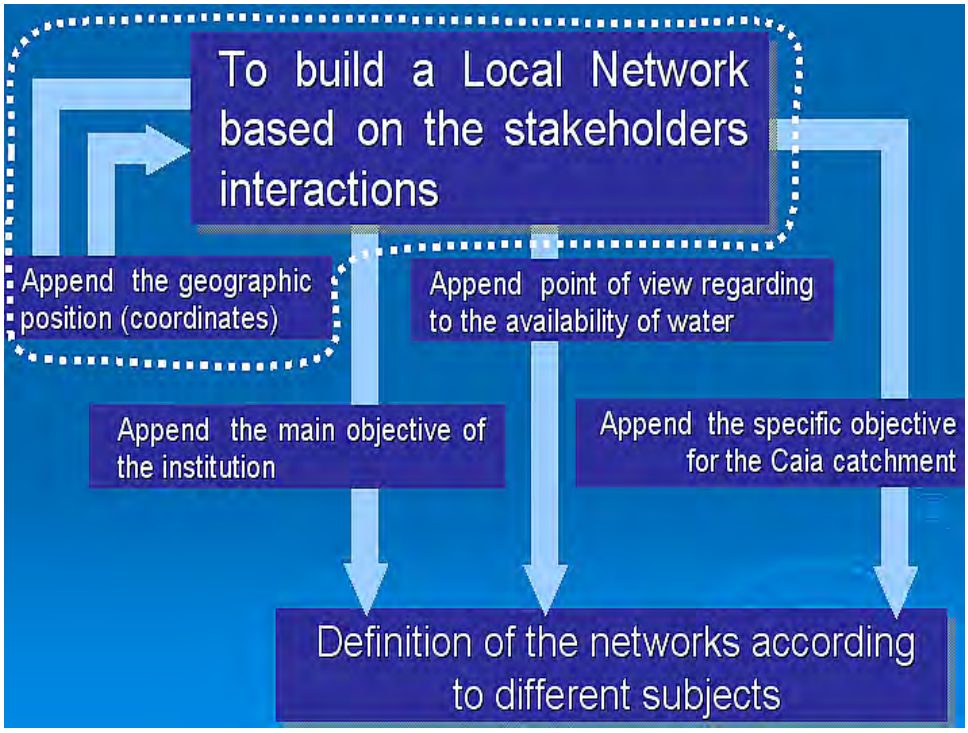

Figure 8 – Identification of Caia's catchment network

From the initial data analysis, the information (directly codified answers or factors summarising groups of answers) was condensed in 28 significant columns. After running the factorial analysis, and based on that 28 columns, the classification of the base-analysis was achieved.

The definition of the networks according to different themes (main objective of institution or point of view concerning water resources availability) shows different groups of stakeholders. This type of analysis corresponds to a multidimensional perspective of the network, and is a advantageous analytical approach to input and circulate some information, normative or rule inside the network. From this step of the analysis, an image of Caia's network structure is achieved. At the same time, this output corresponds to a second step in the process of Caia's network visualisation. This image considers the relative position of the stakeholders, which wasn't taken into account in the beginning of the visualisation procedures.

In fact, when the results of open-ended statistical treatment are added, the relative position of the stakeholders changes. The results show other types of groups, and other types of interactions, driven by the thematic inputs. The images of Caia's network, resulting from a multidimensional perspective according to different thematic points of view, present some significant differences that will be analysed in the next step of the analysis.

After treating the close-ended answers, it is created the first compounded image of Caia's network. This first significant output is, simultaneously, the second step to visualising Caia network. Initially the visualisation of network does not consider a relative position between stakeholders. When it is added the results of open-ended statistical treatment the relative position of the stakeholders changes, appear other kinds of groups driven by thematic inputs, appear in general other kinds of relationships. The images of Caia networks, because of multidimensional perspectives according to different thematic points of view, present some important differences that will be analysed in the next section.

3.2 Data Analysis

The main goal of this analysis is to determine possible interactions among stakeholders, which imply looking not only at individual's social actors, but also at the groups defined with the cluster

analysis. Therefore, it will be possible to answer to some of the following research questions: Is this network fully connected? Are all the ties mutual ties? Are there any isolated actors? How many components can be found in each interaction? Are there any actors that play a leading role in the Caia's local network?

The answers to these questions will help identify which actors or groups may be unique and which are critical to the structure of the Caia's network.

The analysis that follows will focus on the interaction among entities located in the Caia's river catchment, identifying its social structure, the prominence and hierarchy of the main actors. With the support of the network visualization it will be possible to understand how the different actors are positioned in the social network, their roles, which will be very helpful to increase the flows of communication among them and to improve the efficiency of the decision-making process.

The software used in all the statistical procedures was the software ANDAD, and AGNA for networks visualization. The following analyses were accomplished:

- Analyses of descriptive measures applied to the socio-matrices for chosen themes, i.e., flows of information, technical support or objectives of relationships.
- Graph representation of data.
- Search for possible structures (typifying models).
- Analysis of individuals and/or group interactions.

This approach describes the structure of the local network departing from a macro perspective (groups) to a micro perspective (individual). For each one of the relations, general measures such as densities and component structures are calculated. These measures give a broad idea of the manners in which the network is interconnected and about stakeholders that are more isolated.

In addition, for each one of the relationships were calculated measures for the individual actors, like centrality, prestige, etc. These measures give information on how well connected individual stakeholders are.

Moreover, it is assed which actors are the most central, and which are the more prestigious ones. These actors are the ones more visible and recognised by the whole network. A network can have more than one actor that is well-known and well-connected, who could be considered either central or prestigious.

This part of the document will focus on the interaction among entities located in the Caia's river basin, identifying its social structure, the prominence and hierarchy of the main institutions. With support of the obtained network visualisation it will improved the understanding of how players located in this river basin can benefit (or not) from the existent local network, which can be used as a guideline for best flow of decisions.

3.2.1 Macro-structure analysis

The Portuguese governance system is characterised by a strong importance of the central administration. In fact the level of regional administration is very weak, if not completely absent, and results from the power delegation from the central administration. These institutions have, in matter of fact, a strong influence over farmers' or municipalities associations. However, the WFD principles require the existence of regional authorities with decision-making powers related wit water management.

Nevertheless, the last years have seen to emerge some local/regional authorities with decision-making capacities in what concerns water management: Águas do Norte Alentejano, for urban water consumptions; and Conselho de Bacia do Guadiana which is the first step to create a regional authority (as it is proposed in WFD) to manage the water resources at the river basin level. Could these recent changes be revealed in the Caia network interactions patterns?

Density and Cohesion

The analysis of the 18 nodes (stakeholders) and the 95 ties connecting them, show that the Caia's network is characterised by low density (**0.31**) and low level of cohesion (**0.11**). Low density is the main characteristic of Caia's local network, not only within the entities located inside the Caia river basin, but also between different levels of decision making process,

national authorities, regional authorities, municipalities and farmer associations. It can be said that, if the interactions among stakeholders (within the network and with other levels of decision) increase, this could contribute for the improvement of the water management in the catchment.

The analysis of the local networks images allows considering three structural clusters (Figure 10). First, there is a clear separation between farmers associations, municipalities and institutional entities. Second, although the low density of relationships of the network, the level of connections between the groups identified is moderately high. These circumstances can minimise the effect of the low density of the network, since some significant connections are identified within each group, and an important number of ties connect the different groups. Therefore, the flows of communication, in Caia's network, occur mainly between groups of stakeholders sharing the same interests, and not directly between the individuals.

Caia's network presents a medium level of weight density of 0.66. This means that a large number of stakeholders have some kind of contacts with the other stakeholders in the network. However, these contacts can be only unidirectional. Figure 10 gives an image of interaction between members of the same group. This image shows the importance of identification of the groups to analyse sub-phenomena within a network.

Inside of the farmer's association group (Figure 10) a high level of interactions are observed. The justification for this is because almost all of the stakeholders in this group (except GEDA and ESA) participate in the regular meetings the decisions about water management is taken. With the levels of density and cohesion observed it seems that the implementation of any kind of innovation (such as the related with the implementation of WFD) will be rather difficult in this catchment.

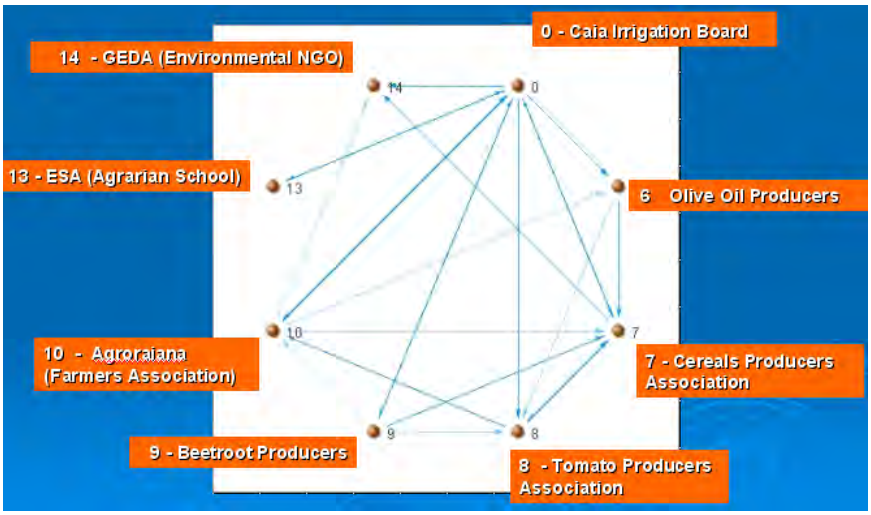

Figure 9 – Interactions between stakeholders of Farmers Associations Cluster

Connectivity

Given the structure of the network identified it is important to try to understand how are the different nodes connected with each other. Each node is directly or indirectly connected with all other nodes and the indirectly paths to other nodes needs to be exploited further in a microstructure analysis (distance between mores then two nodes or groups).

The analysis of the indirect connections is important to see which are the best flow patterns. Table 4 shows the shortest path between one node (INAG) and all the other ones. In this case, the majority of relationships departing from INAG are direct. When the institution usually needs to contact another stakeholder, it has the same alternatives to do it.

When comparing the level of connectivity between them it is possible to identify the relative position of the stakeholders within the network and the simplest ways to relate all the actors to each other. When these socio-matrices are dense (with enhanced level of direct connections), it is expected to find a homogeneous path flow.

to node 0	* 16 0			
to node 1	* 16 1			
to node 2	* 16 2			
to node 3	* 16 3			
to node 4	* 16 4			
to node 5	* 16 5			
to node 6	* 16 0 6	* 16 2 6	* 16 3 6	* 16 4 6
to node 7	* 16 7			
to node 8	* 16 0 8	* 16 7 8	* 16 17 8	
to node 9	* 16 0 9			
to node 10	* 16 0 10	* 16 4 10	* 16 17 10	
to node 11	* 16 0 11	* 16 12 11	* 16 17 11	
to node 12	* 16 12			
to node 13	* 16 13			
to node 14	* 16 0 14	* 16 4 14	* 16 7 14	* 16 17 14
to node 15	* 15 17			
to node 17	* 16 17			

0	Caia Irrigation Board
1	North Alentejo Municipalities Assoc.
2	Portalegre Municipality
3	Arronches Municipality
4	Elvas Municipality
5	Campo Maior Municipality
6	Olive Oil Producers
7	Cereals Producers Association
8	Tomato Producers Association
9	Beetroot Producers
10	Agroraiana (Farmers Association)
11	Reg. Direct for Agriculture
12	Reg. Direct for Environ. Spatial Plan.
13	ESA (Agrarian School)
14	GEDA (Environmental NGO)
15	Water Supply Company
16	Water Institute (National Authority)
17	IDRHA (National Authority)

Table 4 - Shortest path from end user INAG

In Caia catchment, a great irregularity in the relationships between stakeholders is identified, with some nodes with higher levels of contact (Table 4) and other ones with little more then one contact. So far, it is possible to say that Caia has an overall weak level of connectivity**,** where a minimum number of entities can reach the others. The contacts are mainly through the same entities independently of the point of view regarding the network. The multidimensional perspectives among the network reinforce this idea of connectivity lacking.

In these kinds of networks with low connectivity, it is important to analyse the actors in search of the central and prestigious entities existing within the network.

Typologies of Stakeholders

The analysis to discriminate groups of stakeholders is important as a means to identify who the "leader" of the network is. Which are the institutional actors? Which are the residual groups of stakeholders?

Based on the analysis of Figure 11 and Table 5 it is possible to identify these three situations:

- Cluster 1 – Group of farmer's associations (Lead cluster);
- Cluster 2 – Group of national and regional authorities.
- Cluster 3 – Group composed mainly by municipalities;

The examination of the hierarchical cluster analysis reinforces the idea about the existence of one group of stakeholders (Cluster 1 of farmer associations) stronger than the others. This group of stakeholders can be characterised by the more frequent relationships established among them. The Cluster 2 is less strong since its division in two sub-groups: the national authorities and the others of regional character.

In Cluster 3 (Table 5), there is a stakeholder (Regional Directory of Agriculture) which is isolated when a more detailed analysis is performed. This means that there is a certain uncertainty about the position of this stakeholder in this group. On one hand, this regional authority have similar relationships characteristics with the municipalities; on the other hand, this is a regional authority with other expertise which are quite different form the municipalities.

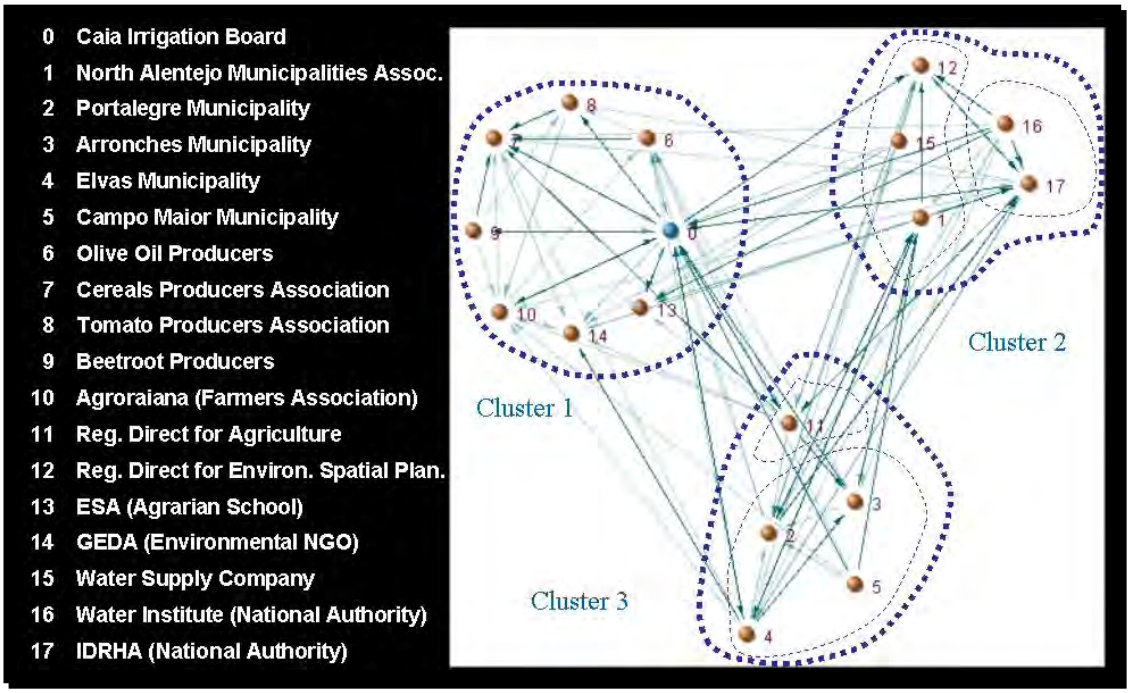

Figure 10 –Base image of stakeholders positional analysis among the Caia network

With the thematic cluster analysis it is introduced another level of multidimensional criteria about Caia's network. The results are expressed in an image of the relationships that shows different points of view. The analysis of the network related with the main objectives of the institutions will help to define another perspective to approach Caia network (Table 5).

	3 Clusters	5 Clusters
Cluster 1	0 6 7 8 9 10 13 14	0 6 7 8 9 10 13 14
Cluster 2	1 12 15 16 17	1 12 15
		16 17
Cluster 3	2 3 4 5 11	2 3 4 5
		11

Table 5 - Hierarchical clusters of Base Analysis

This new thematic perspectives according Caia network could be the key point to a successfully approach regarding the network. When the objective of this approach is closely linked with the thematic network analysed, the chance of success increase because the enter stakeholder (keystone stakeholder) and the contacts patterns are previous identified in order to join stakeholders which sharing same interests according a given specific subject.

If decision-makers want to create some rules more directly connected with water demander stakeholders, the best way to insert this topic is to follow into the group of "Water Demand" actors, or sub-groups (Figure 12). In this specific case is important to define the more influent actors related with Water Demand and Supply. After that, it will be necessary to go deeper into analysis and understand which are the groups with more influence, and higher stability, and what could be the best interface to implement those rules.

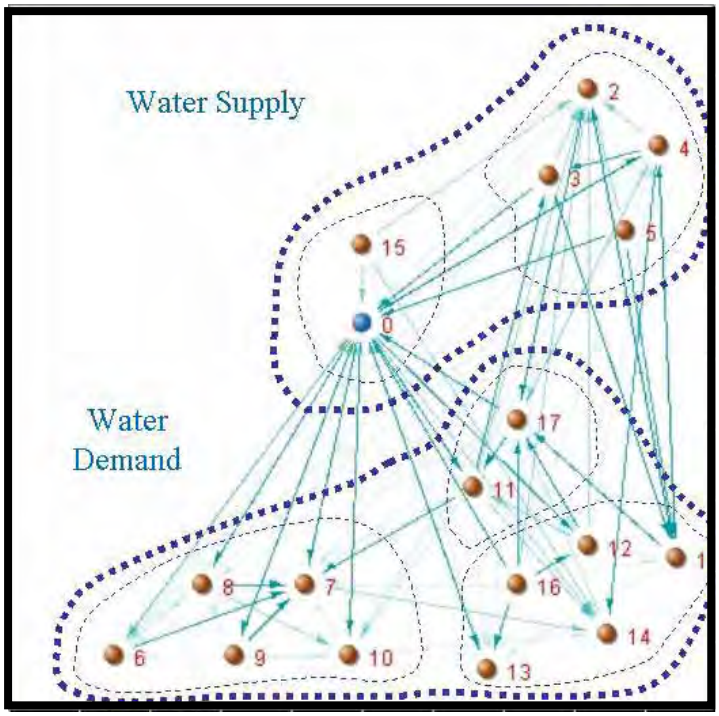

Figure 11 – Image of stakeholders positional analysis among the Caia network including specific objectives of the stakeholders

Another important perspective is given with the "stakeholders' perspectives about water availability" (Figure 12).

Departing from this image it is obvious the existence of great changes in relation with the networks previously analysed. The input of this controversial subject, that divides and compromise, are the opinions of the stakeholders about the alternatives to manage the water of Caia's dam reservoir. In the top of more optimistic institutions are the most important water suppliers: ABC, which supplies water for agriculture; and Water Supply Company, responsible for supply all urban uses of water in the North Alentejo region. On the opposite side of this network appear two entities responsible at regional and national level for the agriculture in Caia river basin, respectively IDRHA and Regional Directorate for Agriculture.

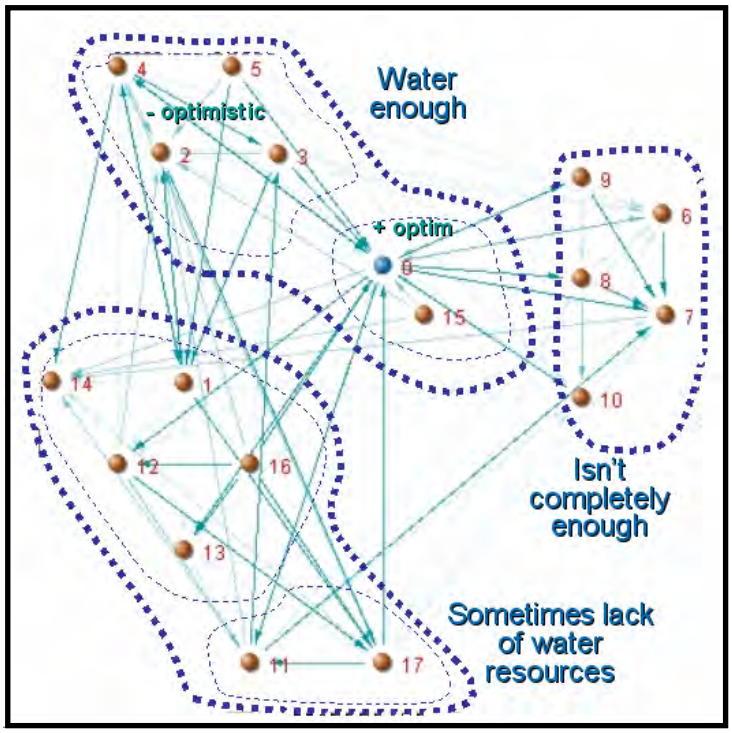

Figure 12 - Perspectives of stakeholders about water availability

Other important subject considered in this group analysis is the specific objectives of stakeholders according the water resources management in Caia catchment Figure 13.

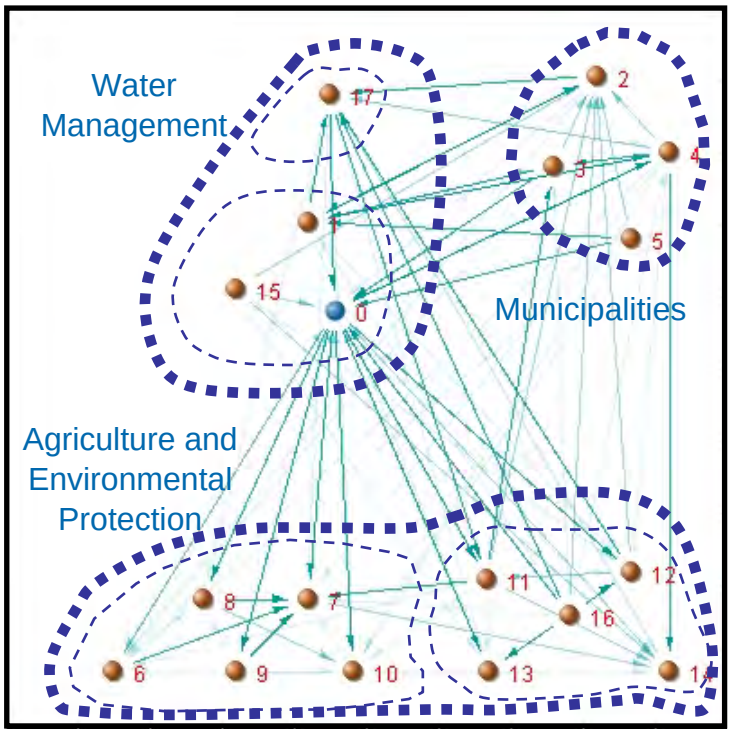

Figure 13 - Specific objectives of stakeholders according the water resources management

In these groups, the strong links between municipalities are obvious. However, it is also interesting to note the meaning of water management group, which appear with relatively strong connections between them. The inclusion of IDRHA (national authority responsible for agriculture) in the same group with Water Supply Company and ABC represents a high level of proximity between this national authority and these two stakeholders directly involved in the water supply at local and regional level. In fact, a strong involvement of IDHRA in the resolution of Caia water resources availability problems is observed.

The agricultural and environmental protection group correspond to a residual group. However, one of the sub-groups represents exactly the farmers' associations and the other one is, finally, the residual group, less consistent than the others are.

3.2.2 Micro-structure analysis

The analysis of the micro-structure of Caia's network complement the macro-structural analysis, specifying some aspects launched during that first approach and opening new perspectives about the individual perspective on Caia local network.

In this phase of the analysis is important to know the actors playing a significant role in the network; and what distinguishing characteristics they have. It will be also determined how well-connected each entity is within Caia network, and how prominent each entity is. Furthermore, this exercise will detail the analysis of the main actors.

Centrality

From a preliminary analysis is possible to say that there are no isolated actors within the Caia river catchment network. However, the links existent between the different stakeholders are not mutual for all the interactions identified. In fact, it is possible to observe some actors that interact with others with a leading role.

To determine which of the actors are more important, the analysis considers all the direct ties made by an actor (both originated and received) and the indirect ties (paths). Five parameters of social network analysis were used to examine the centrality of the stakeholders within this network: emission, reception, sociometric status, closeness and betweenness (Table 6).

Furthermore, three classes of prominence are considered: local centrality, related with the emission degree; local prestige, related with the reception degree; and global centrality, measured by indexes such as "closeness", "betweenness" and "sociometric status.

From the analysis of Table 6 is possible to see that ABC is the stakeholder more involved in relationships with other actors. This involvement makes it more visible to the community of water users. The centrality of ABC is due to receiving and/or transmitting information. Therefore, ABC is the most involved stakeholder in water management. The relevance of this stakeholder is evident: if some entity, outside the catchment area, wants to find some contact, or wants to know the amounts of water available for agricultural use, the best entity to contact is ABC.

ABC is locally central because has a large number of connections with the other actors, which result from its role in supplying water for irrigation. In effect, the existence of one actor with greater local centrality it is very important to understand the internal environment of the local network.

	Stakeholders		Emission	Reception	Status	Closeness	Betweenness
0	Caia Irrigation Board	*0*	**31**	**44**	**4.41**	**0.048**	**102.15**
1	North Alentejo Municipalities Assoc.	*1*	18	18	2.12	0.029	9.48
2	Portalegre Municipality	*2*	18	15	1.94	0.032	9.20
3	Arronches Municipality	*3*	9	11	1.18	**0.027**	1.79
4	Elvas Municipality	*4*	9	**21**	1.76	0.033	10.02
5	Campo Maior Municipality	*5*	7	12	1.12	0.030	3.48
6	Olive Oil Producers	*6*	8	7	0.88	0.036	3.42
7	Cereals Producers Association	*7*	**24**	5	1.71	0.040	9.33
8	Tomato Producers Association	*8*	8	6	0.82	0.034	1.00
9	Beetroot Producers	*9*	**4**	8	**0.71**	**0.027**	**0.00**
10	Agroraiana (Farmers Association)	*10*	10	5	0.88	0.037	9.84
11	Reg. Direct for Agriculture	*11*	10	17	1.59	0.031	5.64
12	Reg. Direct for Environ. Spatial Plan.	*12*	11	13	1.41	0.034	4.38
13	ESA (Agrarian School)	*13*	11	6	1.00	0.034	1.29
14	GEDA (Environmental NGO)	*14*	13	**2**	0.88	**0.037**	5.05
15	Water Supply Company	*15*	10	10	1.18	**0.037**	11.81
16	Water Institute (National Authority)	*16*	16	19	2.06	0.034	13.66
17	IDRHA (National Authority)	*17*	23	**21**	**2.59**	0.036	**25.45**

Table 6 – Measures of centrality according Caia stakeholders in the networks

Global centrality is measured simultaneously by the length and number of carrier and multiple step-path. This indicator captures the position of strategic significance within the network, or the best positioned entities to profit from the structural holes and increase the entire social network efficiency. Of course, this strategic significance depends on intermediaries, but global central actors can have important effects.

One of the characteristics of Caia's network is the high centrality of one stakeholder (ABC), which can be considered as the most important channel for the diffusion of information and innovations (decisions, technical support, procedures, etc.).

Within Caia network is also possible to find other stakeholders that play central roles, i.e. IDRHA, national authority, which has significant values at all the parameters. The (second) higher value of Betweenness of IDHRA represents more potential of an actor to control interface relationships. IDHRA, as a national authority, represents the most central position between stakeholders with head office inside Caia river basin (local level) and entities at other level of decision.

GEDA and Water Institute are globally central entities inside this network. With characteristics completely different, these two stakeholders are important to maintain regular patterns of relationships between different levels of water management that interact within Caia network.

The Water Institute supervises all the activities related with the Caia dam reservoir and all entities that are operating in this area depend directly from its decisions. That is the reason for the important role played by this institution.

GEDA appears as the only NGO operating with its head office located inside the limits of Caia river basin. This actor acquired its position within Caia network acting almost as originator of the contacts. Its prominence can be important to obtain support to launch initiatives or just to influence decision-making process.

Centrality within the groups and keystone entities

Another perspective of centrality is to examine it in the perspective of each group identified with the cluster analysis. With this procedure, it is possible to find sub-structures and to see other centralities, which contribute for the definition of other keystone entities.

The main reason to defining and detecting groups in Caia network is to obtain data zooming/description of patterns of observed structure. These sub-groups are created based on

presented cluster analysis (Table 5). The parameters used to measure centrality in the entire network are now applied to find new centralities inside these thematic groups.

In a preliminary analysis of the groups, Caia's network shows a sample of very interconnected set of entities sharing similar interests, Nevertheless, global values of closeness and betweenness (Table 7) reveal important differences that make emerge other keystone actors.

Cluster	Node	Emission	Reception	Status	Closeness	Betweenness
1	***0***	10	**23**	**4.7**	**0.14**	**18.7**
	6	3	7	1.4	0.10	0.3
	7	**17**	5	3.1	0.14	3.2
	8	7	6	1.9	0.13	1.0
	9	4	8	1.7	0.08	0.0
	10	6	5	1.6	0.11	3.8
	13	4	2	0.9	0.08	0.0
	14	5	0	0.7	0.09	0.0
2	*1*	2	6	2.0	0.17	0.0
	12	6	**8**	3.5	0.25	**3.5**
	15	1	3	1.0	0.14	0.0
	16	10	**8**	**4.5**	**0.25**	2.0
	17	12	6	4.5	0.20	0.5
3	***2***	8	4	**3.0**	**0.25**	**2.5**
	3	**9**	3	3.0	0.25	1.0
	4	2	**5**	1.8	0.17	0.0
	5	3	**5**	2.0	0.17	0.5
	11	**0**	**5**	1.3	0.00	0.0

Table 7 – Measures of centrality by groups of stakeholders

Inside the group of farmers associations (Cluster 1) it is interesting to see that the Cereal Producers Association is the entity that starts more contacts (Node 7). Nevertheless, ABC is still the most central and prominent stakeholder inside this group (Table 7).

Looking inside Cluster 2 (more institutional group) is possible to see that IDHRA lose some importance, when comparing with the prominence of this entity in the global analysis of the network. On the other hand, INAG increase their comparative significance, being the most prominent entity of this cluster. This means that if the objective is to access the part of network more related with national and regional level of decision-making, INAG would be a more successfully way to do it. However, if the objective is to go into an entity with more significance in transversal contacts with local entities, IDHRA is clearly the best alternative in this group.

In Cluster 3 (mainly related with municipalities), the frequency of interactions determines the situation of Regional Directorate for Agriculture that do not start any contact with other node of the group. This entity is included inside this cluster as a residual node. Portalegre municipality is the most central and prominent stakeholder. According to the prestige of Portalegre municipality it is important to refer that the president of this entity is, simultaneously, responsible for other associations (which were not considered in this study: Portalegre Wine Association; and Portalegre Farmers Association). The individual prestige of its president is certainly one in the main reasons of Portalegre municipality level of centrality.

Peripheral entities

As it was said before, since the preliminary analysis of Caia's network it is understandable that in this river basin there are not isolated entities. Somehow each actor is able to reach, directly or indirectly, all the others in the network. However, it is also obvious that these links are not all

mutual and that if some actors give/receive a lot to/from others, some other actors are not so prominent, which means they are not so extensively involved in relationships with all the actors presented in the list.

Some entities have peripheral positions within the network. Beetroot producers can be considered the most isolated stakeholder within the Caia network. The value of emission degree shows some indifference of this stakeholder concerning the activity of the other network nodes. The analysis of the synthetic parameter (sociometric status) reinforces this idea about the peripheral position of Beetroot Producers (Table 6).

Nevertheless, Beetroot Producers are included in the more consistent group, although being the less relevant actor. The reason for this, apparently, contradiction is revealed by the characteristics of the relationships of this stakeholder, which occur totally within the group of farmers associations (Figure 11).

Arronches municipality is another example of exclusion in Caia network, although this stakeholder is reasonable well connected with the other municipalities. The problem is the lack of relationships outside of that group of municipalities.

Other peripheral stakeholder is the NGO GEDA. In this case, it is possible to observe an effort to increase the integration in the network. The value of emission degree is very high, nevertheless almost none stakeholder contact ONG.

Overall analysis of macro and micro-structure of Caia's social network

The patterns of connections that one stakeholder maintains varies, but they often include other stakeholders with other characteristics (like the examples of municipalities with environmental NGO's, or national entities with farmers associations). In addition to a difference in type, the relationships differ in value or strength. A strong network is able to offer much more support and rapid flow of information than a weak network.

The structure of Caia's social network can be standardised to find the position of stakeholders and groups of stakeholders in which they are included. Some issues can lead this discussion:

How important are the relationships between different groups of stakeholders in the framework of Caia catchment?

Can the roles of stakeholders (i.e. purposes vs. opinion about water availability) be the base to differentiate clusters within the network?

Is it possible to measure the structure of a local network based on the practices of sharing space and activities?

Caia's network has some particularities: the global values of network structure are low; however, some groups, defined in relation with some issues are strong. These characteristics give another topic to analyse on this section: Can a set of groups, strong and well defined, balance a weak network?

From the analysis of macrostructure and microstructure results is possible to reveal three structural features of Caia's social network.

There is a clear separation in three groups of the farmers associations, the municipalities and the national level entities.

Within this three groups the density and cohesion is much higher than the global density of the network (except for the farmers' associations cluster).

The level of connection between the groups is high. This feature determines that Caia would be considered as a mean strong network despite its lower density.

One stakeholder (ABC) has great control over the structure of the local network, being this too central entity the obvious reference to any contact with Caia network. Therefore, the centrality and power of this node are the keys to go within this network. However, the power of this entity increases the level of relative entropy on the information flow. Furthermore, ABC is also the strongest interface between the different clusters and the best way to establish contacts among different levels (local, regional and national) of decision-making.

The relationships established among stakeholders result also from previous relations set up by actors sharing same interests, and therefore creating associations that resulted in the definition of different clusters. In each of the clusters identified, some keystone stakeholders represent a

bridge between clusters. The position of these stakeholders, especially if they are the only ones connecting one cluster to another, is advantageous. Not only the individual gains from having access to different sets of information, but also he has the power to control what aspects of this information can be shared with the other actors. In many cases this is what happened with ABC in Caia's local network.

In Caia's network is possible to recognise multiple connections between clusters, with some individual stakeholders assuming in this framework a strong position. Therefore, those stakeholders have accumulated the conditions to maximise their ability to acquire and control more information.

However, when one stakeholder centralise too much the activities of the network some problems are likely to occur. For example, if one stakeholder with a strong centrality within the network comes in divergence with other stakeholders it could, by its dominant position, create a hostile environment to that stakeholder, constraining its participation in the decision-making processes or leading to its exclusion from the network.

3.2.3 A comparative overview

In this point will be presented a brief comparative overview of the results concerning the Portuguese case-study (pilot local network and more complete application of the methodology), Italians and English case studies.

The highest density of Cavalino network is directly connected with its dimension. Cavalino has just nine stakeholders. Vela is the case study with a highest number of relationships in absolute terms, being also the most solid in what concerns the networks cohesion.

In the opposite side appears Caia catchment with the extreme situation: although with the highest number of entities involved in the network, in this case study it is observed the lesser values of sociometric indicators. The main reasons for this disparity derive from the basic characteristics of the selected stakeholders: great geographical disparities (more than 200km between the most distant stakeholders); and a very large set of representative stakeholders (municipalities, farmer associations, one NGO, one University, and several regional and national authorities). In this local network, the foreseeable high density of information flows among stakeholders is however weakened by the profusion of stakeholders that are competing by the scarce water resource.

The Vela case study presents very similar characteristics with Cavalino. This resemblance results also from the proximity of these two Italian case studies. Both of them are based on almost the same number of stakeholders which have similar characteristics.

The Bure and Yare case study (UK) presents a situation positioned between Portugal and Italy in what relates the sociometric variables of the network. These UK local networks are also defined by a large range of interests represented by the stakeholders (in terms of disciplines and in terms of geographical distribution of the stakeholders). The exception is the weighted density: in this variable, that represents the most significant networks intensity value, the UK case study presents one of the highest values, being the frequency of contacts in UK case study very high.

The Cavalino case study represents the situation of dense relationships, but the weighted density can be higher, as in the example of Bure and Yare that presents more intense interactions among stakeholders.

After these networks with great density of interactions it will be focused the analysis of the prominence of the stakeholders that represents a more central and prestigious role, occurring mainly inside of lesser dense networks. The highest level of centrality is the most significant characteristics of the Caia network. The Caia irrigation board plays a very important role in the interface between the local private sector (farmers associations) and the public national/regional authorities. The presence of one stakeholder with this kind of importance will naturally lead the initiative in local community dealings. Based on this highest level of centrality, this network shows a keystone stakeholder very well defined.

After looking at the main characteristics of local Caia stakeholders centrality the main idea is that one actor is considered central because can easily interact with all the others, in the shortest path through other well connected stakeholders. In the perspective of the water

management, this is the stakeholder that can efficiently improve the flows of information in the network, benefiting the whole connection, reaching clusters of other stakeholders already connected among the Caia networks.

Comparing with the other three local networks Caia is much more central than the other ones. Otherwise, the level of entropy is higher on the Portuguese networks. The entropy is a function of centralization and connectivity (density) and in this comparative study demonstrates the strongest level of entropy when the network structure is more complex.

4 LOCAL NETWORKS AND PARTICIPATORY DECISION-MAKING TOWARDS A GOOD MANAGEMENT OF SCARCE RESOURCES

The way societies organise themselves and establish rules to govern their actions will play a major role in determining whether they move toward more sustainable paths. But good governance requires reforming decision-making processes to increase opportunities for public participation, including a wide variety of activities ranging from consultation hearings as part of an environmental impact assessment, to co-management of natural resources. Therefore it requires public debate and problem-solving capacity (Risse, 2002).

Decades of human pressure on natural resources resulted in a new approach to development, which also points to the future but, contrarily to prior approaches, "…to a bleak future of scarcities rather than a bright future of progress…" (Sachs, 2000). Development is only possible when economic fairness, social equity and environmental sustainability are guaranteed. To find solutions to these problems is one of the main challenges of our society.

One of the conclusions arising from the analysis of social network at local case-studies, is that this type of studies must be seen not only as a collection of measures and methods to find out certain parameters about network characteristics, but must be also considered as a tool to help improving the communication within this network. This tool must be at the service of the end users and other keystone stakeholders identified. The advantages of analysing social networks are:

Increasing innovative policies and better operational decisions departing from dialogue and interaction among organisations, previously recognised within the network, with different responsibilities and perspectives according the problems under analysis;

Resolution of conflict and disagreement through consultation of all stakeholders and their involvement in the decision-making processes;

Increasing the continuity and consistency in policy within individual organisations as a result of the building of expectations and interaction with other actors;

Coordination and integration of disparate actions and aggregation of separate budgets, to enhance policy impacts;

Increasing the level of strategic planning and decision-making, through shared agreement reached on essential needs and priorities.

Networks are the essential means for linking different groups of stakeholders that share similar interests related to some subject, and are the mechanism for the exchange of information and services in support of water management processes. Beyond the local networks, the stakeholders identified require the commitment of the decision-makers to cooperate.

In the decision-making processes, social networks operate as an essential tool in the transmission of normative systems, which regulate the decision and allow for the identification of existing problems and potentialities. Social networks constitute structures of opportunity and constraint for the stakeholders and they have proven to be crucial to:

- Facilitate the flows of information;
- Produce better-informed and more creative decision making (reducing uncertainty);
- Increase stakeholders acceptance, fewer delays and more effective implementation;
- Stimulate a more open and integrated governance and more transparency in the decision process;
- Develop a broader knowledge base through the use of stakeholders knowledge and experience;
- Promote social learning as a consequence of a constructive dialogue in which all interests involved identified at the networks (stakeholders, governments and experts) learns from each other.

The application of the MULINO DSS methodology to work out with water management problems will increase the quality of the decisions. However, the success of this methodology depends also of the identification and analysis of local networks, because with this procedure it is possible to know the expectations of the stakeholders and targeting best ways to start

implementing some measures. This process of identification is essential to support any Decision Support System in order to obtain negotiated solutions involving all the interests. Moreover, given that the flow of information is a phenomenon essential to the functioning of local networks, this network will likewise assist the dissemination of this decision-making support tool, and as a continuous source of information to implement it.

GLOSSARY

Arc - The arc is a directional relation that has an explicit origin and destination, represented by a line between entities with an arrowhead signing the destination.

Betweenness - A measure of the global centrality of the actor i, is the probability that the shortest path from actor j to actor k takes a route through agent i. Formally, $\boldsymbol{B}(n_i) = \sum_j^N \boldsymbol{g}_{jk}(n_i)/\boldsymbol{g}_{jk}$ where $\boldsymbol{g}_{jk}(n_i)$ is the total number of geodesics through i, and $1/\boldsymbol{g}_{jk}$ is the probability that the particular geodesic is chosen. A node with high betweenness has great influence over what flows in the network.

Boundary Spanners - Nodes that connect their cluster to others usually end up with high network metrics. Boundary spanners such as Fernando, Garth, and Heather are more central than their immediate neighbours whose connections are only local, within their immediate cluster. Boundary spanners are well-positioned to be innovators, since they have access to ideas and information flowing in other clusters. They are in a position to combine different ideas and knowledge into new products and services.

Closeness - closeness is a second main measure of the global centrality of the actor i. C(ni) = [å jN d(ni,nj)]-1 where d(ni,nj) is the geodesic (shortest path) distance between i and j entities in the network, and N is the network size. To normalise, divide the sum of geodesics by N-1 before inverting.

Cohesion – The computation of the network's **cohesion** index results from the number of mutual connections in the network divided by the maximum possible number of such connections.

Degrees - The networks activity regarding to the study of nodes could be defined using the concept of degrees. This represents the number of direct connections a node has. In the Caia networks, ABC has the most direct connections in the network, making his the most active (with more relevant degree level) node in the network.

Density - The density of a network (D) is the total number of edges divided by the number of all possible edges in that network $\boldsymbol{D} = \sum_i \sum_j \boldsymbol{a_{ij}} / \boldsymbol{N}(\boldsymbol{N}\text{-}1)$. It is the measure of how many entities are related to others in a given network.

Edge - represents a non-directional relation or tie which is non-specific about the origin or destination of the flow on the link. It is illustrated by a line between the interacting agents that has no arrowhead.

Emission degree - The emission degree of a node is the sum of all values corresponding to the edges originating in that node. Computes the emission degree for each node of one network, which is considered as weighted and directed.

Geodesic path – Geodesic path is the shortest path between two nodes i and j. It is measured as the number of arcs required to get from i to j, which is the first power p for which the ijth element of $\boldsymbol{A}^p$ is non-zero: $d(n_i,n_j) = \min\{p\} | \boldsymbol{A}_{ij}^P > 0$ (WASSERMAN and FAUST, 1994).

Centrality – The local centrality is a measure of prominence which reflects the number of direct transmissions from the entity, measured by the outdegree (or row sum) for the entity. Also known as degree centrality.

Prestige – The local prestige is a measure of prominence which reflects the number of the entity's direct receipts, measured by the indegree (or column sum) of the entity. Also known as degree prestige. (WASSERMAN and FAUST, 1994).

Relation - A relation is the collection of ties of a specific kind among a set of entities. Alternatively, consider the mathematical definition of binary relation (ROBINSON and FOULDS,1980).

Keystone sector – This represents the type of entity (business, institution, organisation, etc) in a catchment that plays a unique role and without which the community is fundamentally and detrimentally altered (KILKENNY, 1997).

Node - The node represents the individual entities or actors in networks.

Peripheral Players- Most institutions would observe the nodes on the periphery of a network as not being very important. In fact, as the example presented in the Caia Network the National institutions (located more than 200 km from the catchment receive very low centrality scores for

this network. Yet, peripheral nodes are often connected to networks that are not currently mapped.

Sociometric status - This is considered as weighted and guide of some considered network. The sociometric status of a node is the sum of its reception and emission degrees, relative to the number of all other nodes in the network. A set of statistical parameters (minimum, maximum, sum, mean, variance, standard deviation, absolute entropy, maximum entropy and relative entropy) will be created as well for the sociometric status distribution.

Sociomatrix – A sociomatrix is an entity-by-entity array of data on the relational ties between them. Rows of the sociomatrix represent the sending actors while the columns represent the receiving actors.

Ties - The tie is a relation between two entities in a network. If it has direction it is an arc, if non-directional it is an edge.

Weighted density -The weighted density of a network is the sum of all edge values divided by the number of all possible edges in that network.

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