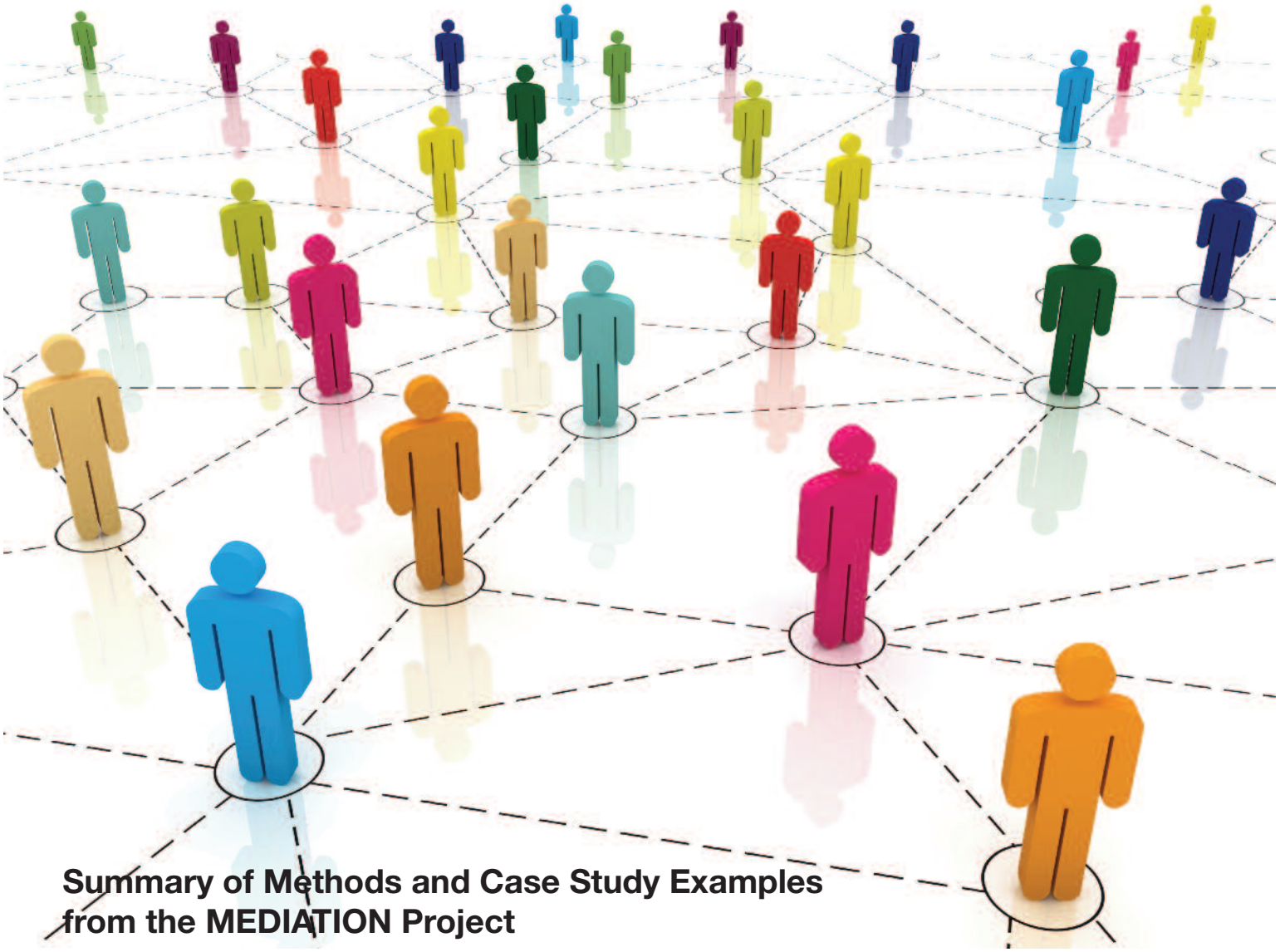
Decision Support Methods for Climate Change Adaptation

8

Social Network Analysis



Summary of Methods and Case Study Examples from the MEDIATION Project

SEVENTH FRAMEWORK PROGRAMME

Mediation

Key Messages

- There is increasing interest in the appraisal of options, as adaptation moves from theory to practice. In response, a number of existing and new tools are being developed and applied including methods that address various sources of uncertainty in making a decision.
- The FP7 MEDIATION project has undertaken a detailed review of these tools, and has tested them in a series of case studies. It has assessed their applicability for adaptation and analysed how they consider uncertainty. The findings have been used to provide information and guidance for the MEDIATION Adaptation Platform and are summarised in a set of technical policy briefing notes.
- **Social Network Analysis (SNA)** analyses social networks and institutional actors (organizations, individuals, interest groups, etc.) and their linkages (socio-institutional relationships), mapping the influence and the exchange of information to assess adaptive capacity.
- SNA explores socio-institutional processes, and identifies the context and governance around decisions. It highlights institutional arrangements and structures, the decision framing of actors, their approach to dealing with information (confidence and uncertainty), the competence for action, and the laws, regulations, values and norms that are likely to guide decisions.
- The approach has high relevance for adaptation. It builds on the growing consensus that adaptation is a process, i.e. that implementing adaptation involves more than a set of technical options. There are important barriers to adaptation that are part of existing socio-institutional processes and these can be revealed and subsequently negotiated through SNA. It can also investigate the evaluation of uncertainty, i.e. how decisions are framed and subsequent choice of appraisal tools.
- The MEDIATION review has considered the strengths and weakness of the approach for adaptation.
- The main strength is SNA provides a formalised method to visualise stakeholder and knowledge networks, and in doing so, to understand them in the context of future action. It provides information on institutional actors and relationships, their decision framing, and the influence and exchange of information for progressing adaptation and overcoming barriers. It can also relate these to qualitative metrics and use these to benchmark progress towards outcomes. Qualitative SNA is quick and relatively easy to do and encourages participation across diverse viewpoints and actors. Quantitative SNA extends to provide correlations on key variables to further understanding.
- The potential weaknesses involve the subjective bias, including participation bias for qualitative SNA, and the high survey size and time needed for quantitative SNA.
- Previous applications of SNA for adaptation have been reviewed, and Mediation case study applications are summarised.
- The review and case studies provide useful information on the range of adaptation problem types where SNA might be appropriate, as well as data needs, resource requirements and good practice lessons. The approach has wide applicability and is considered useful for adaptation planning and the links to choices of tools. Good practice suggestions are included, such as the need for balanced representation in qualitative SNA, and the need for high sample sizes for quantitative SNA.

Introduction

There is increasing policy interest in the appraisal of options, as adaptation moves from theory to practice. At the same time, it is recognised that the appraisal of climate change adaptation involves a number of major challenges, particularly the consideration of uncertainty. In response, a number of existing and new decision support tools are being considered for adaptation.

The European Commission FP7 funded MEDIATION project (Methodology for Effective Decision-making on Impacts and AdaptaTION) is looking at adaptation decision support tools, in line with its objectives to advance the analysis of impacts, vulnerability and adaptation, and to promote knowledge sharing through a Adaptation Platform (http://www.mediation-project.eu/platform/). To complement the information on the Platform, a series of Policy Briefing Notes have been produced on Decision Support Methods for Climate Change Adaptation.

An overview of all the decision support tools reviewed is provided in Policy Briefing Note 1: Method Overview, which summarises each method, discusses the potential relevance for adaptation and provides guidance on their potential applicability. The methods considered include existing appraisal tools (cost-benefit analysis, cost-effectiveness analysis and multi-criteria analysis), as well as techniques that begin to address aspects of uncertainty (real options analysis, robust decision making, portfolio analysis and iterative risk (adaptive) management). It also includes complementary tools that can assist in adaptation assessment, including analytic hierarchy process, social network analysis and adaptation turning points. Additional information on each method is presented in a separate *Policy Briefing Notes* (2 – 10).

This *Policy Briefing Note* (Note 8) provides a description of **Social Network Analysis**. It then places SNA in the context of adaptation and identifies strengths and weaknesses. Two case studies from MEDIATION highlight issues in applying the tool to real decision processes. More detailed information is available in MEDIATION deliverables, and sources and links on the MEDIATION Adaptation Platform...

Description of the Method

The varying definitions of the term 'social network' reflect its conceptual and methodological development initially in mathematics (graph theory) and sociology, and more recently in environmental sustainability and related interdisciplinary areas, particularly resilience of social-ecological systems.

Network research focuses on human or organizational actors and their social relationships, and connections among them. For the purposes here, 'social network' refers to institutional actors and their linkages, as well as other actors (individuals, organizations, interest groups etc.). It relates to the analysis of governance and decision-making networks, which are close to the concepts of policy and governance networks (e.g. Blanco et al. 2011). By including multiple types of actors it recognizes that informal ties as well as formal ones are deeply involved in 'governance' (e.g. see Pelling et al. 2008).

A number of methods are emerging that can identify the various actors (or stakeholders) involved in decision processes, and map out these linkages. These can be represented (visually) and analysed with network maps. These can be further analysed, in qualitative or quantitative terms using social network analysis (for a summary see Taylor et al., 2012). The background and key benefits of the approach are provided in Box 1. Participatory social network mapping and analysis reveals insights about the substance of these relationships by making explicit the types of flows between actors (e.g. information, money, advice, policy, etc.) and the perceptions of influence and power in the network. Quantitative SNA provides a variety of measures/indicators to help describe the overall relational structure of a social network, as well as the roles of individuals within it.

SNA can provide insights which can then be explored further with other methods, notably follow-up interviews, statistical analysis, agent-based modelling and participatory scenario creation. SNA can be undertaken using qualitative or quantitative methods. The main difference is that quantitative SNA graphs are 'whole' networks rather than qualitative ego-centric networks based on the perception of (usually) just one actor. They are also more comprehensive (i.e. more nodes and links) and can be quantitatively analysed with SNA software using standard statistical tests.

Box 1: Key features of network mapping and social network analysis

Adapting problem framings. The initial visualization of a stakeholder-knowledge network can provide areas for further exploration and research, e.g. identifying malleable barriers (Moser & Ekstrom, 2010) or informal networks and 'shadow spaces' (Pelling et al. 2008), as well as 'bridges', 'boundary-spanners' (Berkes and Folke, 1998) and different types of 'flows' of resources including 'informal capital'. These can be highly significant in facilitating change and influencing policy processes, even if intangible in nature. It is quite common to find 'discourse coalitions' with a shared understanding of the problem, but not necessarily the same 'world-view', or 'advocacy networks' where the 'world-view' may be the same but approaches differ (Turnpenny et al., 2005). Social network analysis can help understand how and why actors behave the way they do, through analysis of the structural pattern of relations (topology). It provides valuable insights to problem framings and how uncertainty is dealt with. These characteristics help in climate adaptation 'problem framing' and understanding different decision-making regimes.

Facilitating collaboration. Social processes express the structural pattern of relations in networks and show how outcome variables influence how networks change and evolve over time (Borgatti and Foster 2003). The existence of subgroups or clusters can affect the level of cohesion. For example, weak ties can have negative effects on the capacity of subgroups to collaborate. The issue of temporal as well as spatial scales is significant, since the time horizon for decision lifetimes amongst actors can act as a barrier (UK CCRA, 2012). Working cooperatively and collaboratively across a network appears to be an effective way of creating change. Single organizations can access (and benefit from) the depth and breadth of resources but also the knowledge, understanding, skills and expertise needed to build adaptive capacity. Such work is challenging to coordinate, requiring skill and resources, which can be provided by a 'Linking Pin' organization (Carley and Christie, 2000), i.e. for cross-organizational support. Network mapping can identify areas where these changes can occur and the discussion and analysis of conflicting or synergistic goals (barriers to cooperation and collaboration). Identifying these goals is also part of the participatory process when creating network maps. Not all flows are 'positive'. Bodin and Crona (2009) cite examples of the correlation between network density and joint action. They also note that there may be a threshold above which network density becomes counter-productive in facilitating collective action (e.g. Oh et al., 2004 in Bodin and Crona, 2009) due to the homogenization of information and a lack of 'new' knowledge leading to less efficient resource use and/or reduced capacity to adapt to changing conditions.

Agents of change. Network topologies can be analyzed at the network-level, but also at the node-level focusing on institutions or actors. Assessing the position of the actor in the network and the number and strength of their relationships reveals their structural position to influence other actors. The centrality of an actor allows analysis of the level of influence, but also the role they can play in the network as a bridge that connects others (Cash et al. 2002). An actor connecting with many others has the ability to influence the flows between actors. Identifying central actors is a useful way to understand dominant decision framings, how these are used and the effect on collective action. In this regard, central actors located in strategic positions can be potential 'agents of change' in the network or 'adaptation champions'.

Inter-agency coordination. Options identified by different parts of a governance system often relate to who has control over the decision process, jurisdiction, political interests, funding, etc. (Renn, 2008 in Moser and Ekstrom, 2010). If the breadth of the system of concern covers many jurisdictions, the issue requires cross-coordination to implement options (Moser & Ekstrom 2010). The beneficial aspect of clusters is that they may facilitate the development of specialized and tacit knowledge within their own sub-groups. This is valuable for the knowledge diversity of network as a whole, provided that there are also mechanisms for knowledge transfer and boundary-spanning (Berkes and Folke, 1998) to facilitate 'joined-up thinking' between specializations, to lead to new knowledge and action. This can enhance integrated management and cross-sectoral planning. Without knowledge

transfer, the opposite effect can manifest itself – very low collaboration and cooperation or reconciliation of actors with differing goals and objectives.

Types of Networks. A simple illustration of types of network topologies is shown below (Figure 1). These examples outline different types of networks based on number of peer connections, density of relations, role of boundary nodes between isolated networks and degree of cohesiveness, inheritance of links as organizational structures, subgroups interconnectivity and degree of network centralization.

Type 1. Individual action predominates. While people are connected in various ways, most actions are at the organisation/individuals own level and independent of what others believe or are doing. In this type of network, the psychology of individual action dominates. At this level, there may be a diversity of approaches to uncertainty and there is little need for a consensus view. The construction of the problem is usually highly constrained and mostly short-term with rather limited information on long-term futures.

Type 2. Individuals and groups are connected in an egalitarian space. There are various links but the network tends to be 'like-minded' and the structure of the problem is similar across actors. Uncertainty may not be explicit—rather reduced to tacit assumptions common in peer networks and reflected in cultural and group norms rather than a science-policy dialogue as such.

Type 3. Many organizations have hierarchical decision making with a leader (and even an meta-level organisation e.g. a Board) defining policy that is translated into strategy and action. Uncertainty can be explicit, although it tends to be wrapped into how the organization is structured and procedures that are in place for other purposes. Co-management would be the opposite to this, where multiple actors are involved in the governance to varying degrees as opposed to top-down centralized management. Adaptive co-management emphasizes flexible joint management processes, which will allow the continuous application of new knowledge where relevant (Bodin and Crona, 2009).

Type 4. A hybrid of two or more kinds of networks, which is often the reality. Two egalitarian networks for instance might be linked, each with its own approach to uncertainty. In such cases, there is more than one decision framing in play and uncertainty may enter the decision in different ways.

Figure 1. Illustrations of peer-oriented network types.

Type 1 (left): Individualistic, few links between nodes.
Type 2 (centre): Egalitarian more connected.
Type 4 (right): Multiple networks in a hybridisation.

There are many ways to apply SNA to a particular context. The main steps in quantitative and qualitative SNA are outlined below.

Quantitative Social Network Analysis

Quantitative SNA aims at capturing the entire relevant network. The steps for quantitative social network analysis are:

- Clarifying objectives and defining the scope of analysis (e.g. mapping a knowledge domain).
- Developing a survey methodology and designing the questionnaire.
- Identifying the participants (network) and providing justification for boundaries (if appropriate).
- Collecting survey data and gathering further information from other resources.
- Analysing the data through formal methods.
- Reviewing process and outcomes to identify problems/opportunities.
- Designing and implementing actions to bring about desired changes.
- Mapping the network again after an appropriate period of time.

This is a resource intensive task, and field research requires very high response rates, and high resources, as any missing data can weaken the analysis. Other approaches using existing data (e.g. co-citation networks, online databases, household surveys) can also be considered, though it is not always easy to extract relational information or perform suitable data transformations.

Qualitative Social Network Analysis

Qualitative social network analysis or social network mapping (SNM) takes advantage of the early steps above – the interviews, surveys or focus group discussions – to elicit information on the relevant networks. It can facilitate rich discussions, shared understanding and increased awareness between different stakeholders. This can be part of a rapid appraisal before detailed analysis begins. It can also identify entry points for policy influence (Turnpenny et al., 2005) and other 'flows' of resources which can include 'informal capital'.

A number of approaches and tools can be used for network analysis. Following Schiffer (2010), the NetMap guidance is a useful example for applying the approach in a participatory way. The method is usually applied using flipcharts, post-it notes and flat counters with a group of stakeholders who are split into homogeneous groups related to the type of institution they belong to e.g. Government level representatives, NGOs, farmers, etc.

Once the adaptation research question is well defined, participants go through the mapping exercise including an analysis of the network, and then come back into plenary for a discussion of the different networks from the different stakeholder perspectives. This enables a better 'shared understanding' of differing world views.

A range of software exists for both quantitative and qualitative SNA. This includes software for visualisation and analysis, such as GEPHI, UCINET, ORA and NetDraw.

The Application to Adaptation

The IPCC special report on extreme events (IPCC, 2012) confirms the viewpoint of adaptation as a socio-institutional process, defining adaptation as a **process of adjustment** to the actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.

There is now an increasing body of research on the role of socio-institutional networks in climate adaptation as there is for natural resource management (Bodin and Crona, 2009, Stein et al., 2011). Downing (2012) contrasts a predict-and-provide viewpoint with a process-based understanding of adaptation. Berkhout et al., (2006) found that many of the resources required for carrying out the process of adaptation lie outside the boundary of a particular organization.

As a result, inter-relationships between organisations are influential in determining how (and if) adaptation processes will occur. Following from this, it is important to identify the existing socio-institutional landscape and feedback processes in climate adaptation research, to speed up the necessary 'climate-adapted routines and capability to be developed' (Berkhout et al., 2006). This process-based understanding requires a 'mapping' of the problem framing and actors. SNA has the

advantage of providing a baseline (the current stakeholder regime) while enabling various institutional scenarios of future adaptation processes to be evaluated. With qualitative and quantitative analysis, SNA provides a deeper analysis of institutions than simple inventories or static checklists. See Box 2 for the main features in the analysis of network topologies.

The application of SNA to adaptation is well suited to evaluating how socio-institutional networks and relationships between the actors (and their actions) might evolve over time. It is also necessary to consider the differences in decision framing and the links to uncertainty. This includes four common levels of decision framing:

- Architecture of stakeholders and knowledge;
- Defined decision boundaries, i.e. what is in scope;
- Decision making, i.e. the methods, tools and metrics;
- Implementation and organisational responsibility for specific strategies and actions.

These are features of an adaptation pathway (see Box 3). Information on these aspects allows analysis of the value of information in making a decision, and on the consideration of uncertainty, noting the framing of the uncertainty has a strong socio-institutional component, which cuts across all four of the areas listed above.
Understanding the framing of the problem across actors can therefore be informative in looking at adaptation and the context for decision making under uncertainty.

Strengths and Weaknesses

The MEDIATION project identified the strengths and weaknesses of different approaches to SNA. A summary is outlined below.

The main strength of Social Network Analysis is the information it provides on the existing institutional actors and relationships, the existing decision framing, and thus the influence and exchange of information for progressing adaptation.

Quantitative SNA provides additional information and can explore correlations between network variables and attribute variables or other social indicators. However, it requires a large sample size, or ego-centric partial networks. It tends to focus on methodology and technical issues rather than on hypotheses and theories, and can be subject to the over-interpretation of results. Further, data are often difficult and resource intensive to obtain, and empirical studies are often quite small, which can make it hard to use for exploration of alternative measurement strategies

Qualitative SNA is quick and relatively easy to do and encourages participation across diverse viewpoints and actors. It also avoids some of the more complex classifications or jargon involved in more formal quantitative applications. The engagement also reveals insights that would be difficult to get any other way. The disadvantages are that results are highly dependent on which actors are involved in the exercise, and their participation which can bias results (high subjectivity). It can also be difficult to integrate different perspectives to produce cohesive maps of whole networks, especially where multiple scales are involved or to bring together actors that have very different perspectives.

A key issue (and potential weakness) in SNA is how the question is framed, because this influences the responses. This structured subjectivity contrasts with other potential methods.

Box 2: The Concepts of Networks

The structure of a network is comprised of a topology of points, linkages and structural forms. These differ within networks, depending on the type of actors, which actor is the focus, whose perspective is used, and affect social processes such as knowledge transfer, information sharing, flows and exchange of types of capital, consensus building and power relations. Key issues and illustrative examples for climate adaptation are provided below.

Strength of connections. The 'strength of connections' refers a) to the proximity of actors to each other and b) the number of links between actors. The closer the actors are to each other and/or the more the links, the stronger the bond. Ties within cohesive subgroups are known as 'bonding ties'. Adaptation example: an existing research network with strong ties will be more productive than establishing a new network solely dedicated to climate adaptation.

Bridges. Bridging actors link actors and institutions. They may span 'clusters' of actors who have specialized knowledge and provide access to new knowledge for others. Links between subgroups are known as 'bridging ties' and are important for innovation and adaptive management. A lack of links to important or influential actors can also be a barrier and an area where 'boundary-spanning' actors (Berkes and Folke, 1998) have an important role to play. Example: the Dialogue on Climate and Water bridges two communities of practice.

Clusters. A cluster is where actors have significantly more ties between group members than between members and non-members. The existence of many sub-clusters within a network can be a barrier, as low 'network cohesion' can produce 'us-and-them' attitudes or keep organizations with different agendas apart. Example: integrated assessment modelling is a technical area that tends to concentrate learning among specialists, with relatively limited access from other disciplines or perspectives.

Centrality. There are several types of centrality: for example, degree centrality (number of ties an actor has) and 'between-ness' centrality (the degree to which an actor connects other actors who would not otherwise be connected). Degree centrality can be problematic if there is too much responsibility for one actor. Example: The Intergovernmental Panel on Climate Change creates a central tendency in networks as a singular focus for expertise on climate vulnerability, impacts and adaptation.

Homogeneity versus heterogeneity. Bridging ties can be important in building trust amongst unconnected actors and facilitating information exchange. Bridging ties link clusters of homogeneous actors to other different, yet homogeneous actors. These ties can link different types of actors both vertically and horizontally. Example: participatory processes that engage social entrepreneurs, local decision makers and global experts are vastly heterogeneous and are a challenge to manage as productive adaptation processes.

Goals – conflicts and potential synergies. Moser and Ekstrom (2010) outline that adaptation may be 'initiated in non-climatic windows of opportunity (e.g. infrastructure replacement, renovating a building) or moments of potentially high human 'agency' (Ballard et al., 2012). The differing goals of various actors can create obstacles to adaptation, because institutional goals or values and norms are not aligned, or there is disagreement about the strength of the climate signal (Berkhout et al., 2006). Example: social network analysis in small islands highlights the disparity between the rights of local resource-based livelihoods and the imperative of long term coastal zone management faced with sea level rise.

Influence. The perceived influence of different actors can reveal insights into why overall objectives on climate adaptation are not being met. Outliers are interesting if they are influential and do not possess a large number or 'bonding' or 'bridging' ties. Insufficient linkages leads to less potential for intervention and capacity building. Example: the shift from 'impacts' as an environmental issue to 'adaptation' in the allocation of finance is also one of influence between relatively weak ministries and the role of the state in managing the economy.

Box 3. Network analysis and future stakeholder regimes

Institutional scenarios and opportunities. Institutional mapping allows a group (stakeholders or experts) to play out scenarios of different knowledge-action networks. It is often useful for thinking through particular outcomes which may be 'known' by stakeholders, or 'anticipated' but not readily articulated. Often, building adaptive capacity is seen as adding staff or increasing skills within an organization. However, the real challenges are likely to require new institutional relationships and even new players.

Given a map, participants can take an actor out of the network (or add a new one) and ask 'what changes? 'Not identifying, and losing, 'windows of opportunity' for making decisions is a common impediment to effective and strategic adaptation planning. While such windows may be internal to an institution, often they realign the network as well. Thus, differing agendas and time-horizons for decision-making in different institutional bodies can lead to conflicts in implementing adaptation plans or result in missed opportunities for collaboration or for facilitating the emergence of a demand-led institutional entity.

Building adaptive capacity and avoiding 'lock-in'. The topology of a network can help to explain how actors and networks behave and some topologies are more likely to foster adaptive capacity and governance than others (Sandström and Rova 2010).

Low density networks with few or weak connections between actors or sub-groups or with strong hierarchies are associated with lower potential adaptability because of the divergence and competition of views, absence of a common understanding and common problem definition, as well as common decision space for the management of natural resources. In this context, it is more difficult to strive for legitimacy of formal management rules (Sandström and Rova 2010, Bodin and Crona 2009).

On the contrary, denser networks or decentralized and less hierarchical networks can facilitate bridges between disparate views and help formulate shared understandings and framings of the problem leading to a more sound management strategy based on collective action. This can be important over time where it is key to remain flexible and adaptive to new information as it arises instead of becoming 'locked-in' to a particular pathway because of previous investments.

It has been suggested that a successful management strategy (particularly, in governing natural resources) is one where actors, during periods of stability, develop new relational ties with various other actors and stakeholders which can be drawn upon in times of change (Olsson et al., 2006) and this resonates with the proposition that informal networks or 'shadow spaces' are especially useful in times of changes (Pelling et al. 2008).

Adaptive management. Generally speaking, empirical studies support the hypothesis that the higher the network density (i.e. the number of existing ties divided by the number of possible ties), the more potential for collective action due to increased opportunities for communication, and over time, reciprocity and trust (Bodin and Crona, 2009).

This support can facilitate 'joined-up' and integrated thinking. If the network is responsive and flexible, this density is also an important aspect of 'adaptive management' as it allows the development of knowledge though the exposure to both an increased amount of information and new knowledge through boundary spanning actors who act as vehicles for knowledge transfer. In the absence of these actors, there can be areas for intervention, either by groups coming together in new institutional arrangements, facilitating new connections between actors, or through the creation of other 'platforms for communication' such as online communities or the formalisation of 'networks'.

Key strengths

- Can generate an understanding of socio-institutional structures, actors and linkages, and ways to improve information and knowledge transfer
- Can provide information on decision framing and key actors.
- Can provide quantitative information and correlations to understand network variables (quantitative SNA).
- Qualitative SNA is quick and relatively easy to do and encourages participation across diverse viewpoints and actors.

Potential weaknesses

- Subjective bias and can be difficult to generalise.
- Time-consuming, intensive process (quantitative SNA).
- Does not have a temporal or spatial dimension.
- Networks have artificial boundaries (often necessarily).
- Design of process is critical to get as many differing viewpoints as possible.

Case Studies

The MEDIATION study has reviewed existing literature examples and has applied network analyses to a number of adaptation case studies (see Varela-Ortega et al., 2013, Bharwani et al. 2012, Zhu and van Ierland, 2013 for more details). The case studies are summarised in the box below.

Case Study 1 – Quantitative Social Network Analysis in Finland

The first MEDIATION case study, focusing on Finland, used egocentric SNA to investigate farmers' involvement in environmental conservation through their relationships with other actor-types, i.e. with conservation stakeholders. The research was investigating the effectiveness (for the local ecology and economy) of agri-environmental schemes (AES), and their role as potential adaptation options in the context of future climate change. These schemes are an existing policy instrument for enhancing biodiversity in Finnish agricultural landscapes, promoting active management and maintaining the conservation values of semi-natural grasslands and other traditionally managed biotopes.

A survey was sent to farmers in two locations (SW Finland and Pirkanmaa), most of whom had an agro-environmental agreement (AEA) in place. The survey collected information about farming practices, farmer attitudes towards conservation, and other farmer attributes. It also included a section (related to SNA) which asked whether they had a connection or not to each of 14 different actor categories. The response rate was 20%, with just under 400 answers, with over 250 of these fully completing the survey section on their networks.

The network analysis method was adapted to understand the role of different organisations in the communications about adoption of AEAs and the channels of potential influence and dissemination. Information about networks was included as an attribute, and was used to visualise and to make statistical comparisons across several other variables.

While a complete network and structure properties could not be constructed from the responses, because connections were directed to categories of actors/ actor-types rather than individually (uniquely) identified actors, the survey provided important information on individual networks.

The overall set of responses were analysed calculating the proportion of farmers having a connection with each actor type. Several actor groups had an overall connectivity of > 80% (administration of rural affairs, Forestry Union, Other farmers and forest owners and local hunters).

Figure 2 shows results presented using R statistical software (R Core Team, 2012) and its packages for network analysis and visualisation (Csardi and Nepusz, 2006).

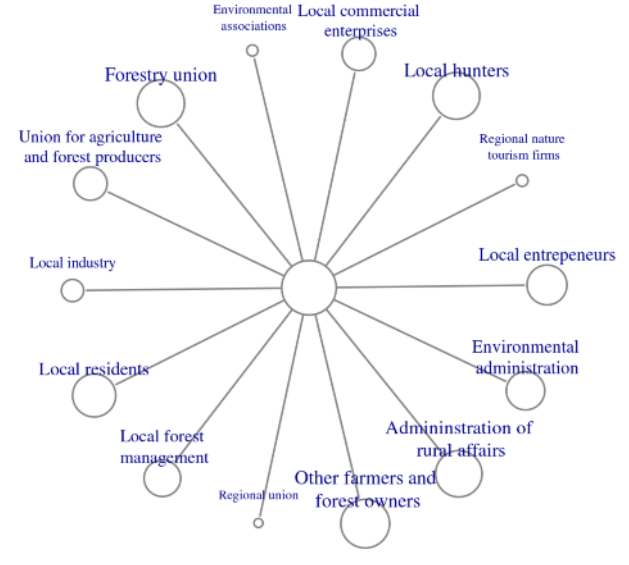


Figure 2 Caption-size of node labels and size of node is scaled to proportion farmers of connections.

Subgroups in the farmer responses were analysed and compared. Subgroup categories were farm location (alternatives were SW Finland and Pirkanmaa), farm type (alternatives were animal husbandry and crop) and type of AEA (alternatives were normal and special). Differences among each pair of alternatives were assessed visually, by comparing network diagrams, and statistically, by using Chi-squared tests of differences in the proportions. The tests showed that, significantly,

1) farmers in Pirkanmaa were more connected to local forest management than farmers in SW Finland
2) farmers with special AEA were more connected to environmental administration and less connected to local industry than farmers with normal AEA
3) farmers involved in animal husbandry were more connected with the Union for agriculture and forest producers than farmers involved in crop agriculture.

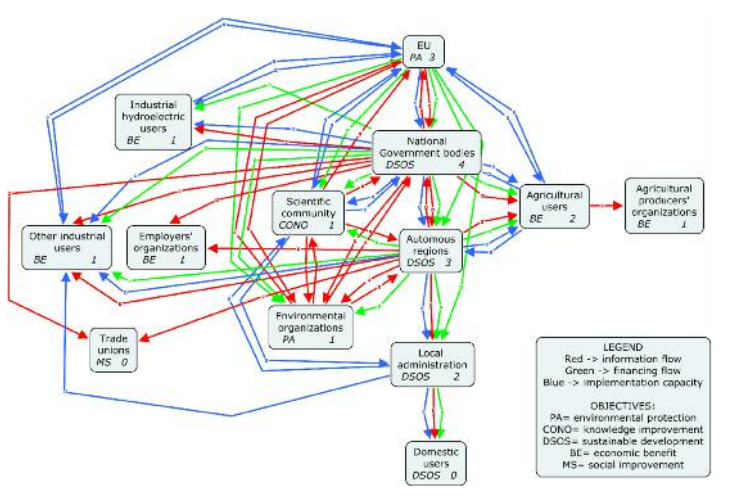
The analysis showed differences in the way that various farmer subgroups connect with other conservation stakeholders. While further network analysis and sampling would help in understanding the networks and the wider survey results (i.e. regression analysis), the study has provided interesting findings that identify areas for further research.

Case Study 2 – Qualitative Social Network Analysis in Spain

The second case study focused on Guadiana river basin, presenting an illustrative example of adaptation decision-making in the agricultural and water sectors (see Varela-Ortega et al., submitted). This basin is expected to be one of the most seriously affected by climate change in Spain, with a potential decrease in water resources of 11% by 2030 and associated impacts on irrigated agriculture. A social network mapping exercise was undertaken to analyse the social and institutional framework of climate change adaptation. This was applied to a group of basin stakeholders: the water administration, representatives of the main irrigation communities, active environmental groups and the different climate change offices involved in the basin (National and Regional). The analysis focused on 'how are climate change adaptation related decisions taken in the Guadiana basin, in the agricultural and water sectors?'

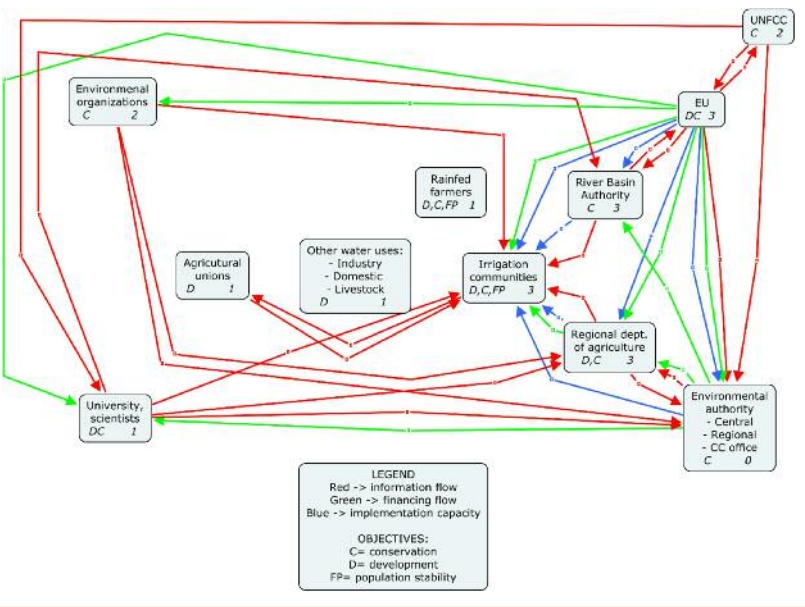
A stakeholder workshop was used, grouping attendees into water administration, farmers and environmental / CC organizations. Each group built a socio-institutional network map, which were subsequently discussed to help learning of all perspectives. Each box represents a different stakeholder group (name, main objective, and influence [where a higher number indicates higher influence]). The linkages represent flows of information, funds and implementation capacity between stakeholder groups.

The network map of water administration officers was a hierarchical network structured in several blocks of actors: administrations, water users (agrarian and non-agrarian uses), trade unions, scientific community and environmental organizations, with the administrations clustered in the middle. The number of links is quite high, showing a strong relationship between actors (a 'discourse coalition' (Turnpenny et al, 2005) with a 'shared world view' or Type 3 network where uncertainty can be explicit, although it tends to be embedded in how the organization is structured and procedures in place .



The discussion revealed that to improve these relationships, there would need to be more willingness to solve problems, increased participation, resources to backup compulsory environmental regulations and improved connections. The group also provided information on changes in the social-institutional framework that could improve decision-making for climate change adaptation.

The network map of farmer representatives (from irrigation communities and independents) was very different, and was more fragmented with a lower number of connections and some disconnected actors. They identified different groups and had different perceptions. This is a Type 1 type of network where individual action predominates. Adaptation was considered from a local and independent perspective, with a diversity of approaches to uncertainty, and is highly constrained and mostly short-term in nature. The discussion on how to improve the system included an increase in trust, the exploration of synergies, and for key links to be improved. This reflects an 'advocacy coalition' with a shared worldview but where technical approaches differ (Turnpenny et al, 2005).



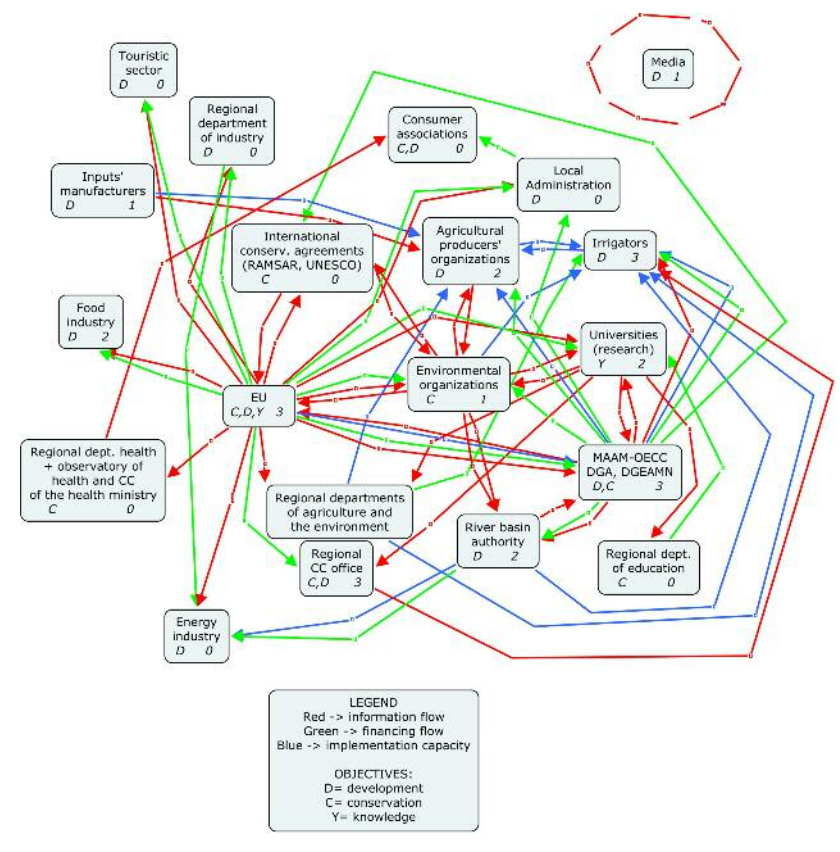
A number of missing connections were also identified, as well as a need for more capacity for decision-making and action, training, implementation capacity and funding between the irrigation communities.

Finally, the members of environmental NGOs and climate change officers designed a homogeneous network, with no evident clusters. The number of links between actors is high, and none of them is disconnected.

This is a Type 2 egalitarian network where everyone tends to be 'like-minded' and the structure of the problem is similar across the network. Uncertainty may not be explicit but reduced to tacit assumptions and reflected in cultural and group norms rather than a science-policy dialogue. The goals of the different actors reveal two important conflicting objectives in the network: conservation and development. The group suggested synergies by developing tools and strategies with co-benefits for both objectives, raising awareness about climate change and continuing to involve the media.

Social Network Analysis

Comparing the three networks, the groups identified two main groups of actors: water users and policy makers. However, there were important differences: the water users network had a big emphasis on agricultural uses. All groups identified the multiple scales (local, regional, national, European) and different sector, but the farmers had a more partial view of the system with a lower number and less detailed actors. Only one group (the environmental network) identified the media as an actor.



There are also differences in the flows across the three networks. Stakeholders from the water administration perceived themselves as the main information providers in their network, with a cascade from regional and national administration. Farmers perceived reciprocal flows (two-way arrows), but considered environmental organizations and scientists as main information providers. The environmental actors considered the main information provider was the EU followed by environmental organizations and universities, but via different channels. Similarly, the maps reveal differences on the financial flows and implementation capacity between the groups. The strength and number of connections (lines) in the maps also show important differences. These also indicate the influences, though all groups consider the most influential actors were the EU, the national government and the regional government, together with irrigators. Finally, the groups all identify conflicting objectives of conservation/environmental protection and development/economic benefits, though the different groups had different views on which should be prioritised.

Overall, the exercise revealed important differences between the three networks. While the water administration was focused on a traditional top-down approach to decision-making, with a hierarchical structure to other actors, agricultural users (irrigators) had an individualistic view of the process. The environment and climate change representatives had the most holistic approach and deepest understanding of the adaptation process, with highest representation of stakeholder groups in their network diagram. All agree on the influential actors and those with most influence for adaptation. The figure illustrates key omissions and connections (i.e. weak lines to improve). The mapping was discussed by the stakeholders and used to highlight and find ways to overcome barriers.

The workshops helped to increase awareness and brought attention to the current weakness of the socio-institutional framework and areas to explore, as well as bringing the different groups together, helping to identify steps to improve linkages and information flows.

Discussion and Applicability

The review and case studies provide a number of practical lessons on the application of social network analysis to adaptation. They provide useful information on the range of adaptation problem types where SNA might be appropriate, as well as data needs, resource requirements and good practice.

The application of the qualitative approach is very broad, and can be applied to most adaptation settings. The approach can be useful for adaptation planning, decision-framing, uncertainty analysis and the links to choices of tools. The quantitative approach provides important additional context for progressing towards adaptation implementation, though there is a need for balanced representation (i.e. of participants) to avoid subjectivity influencing results. The quantitative approach can provide a more detailed analysis, providing correlations, but there is a need for high sample sizes, thus the added time and resources limit the approach to more specific applications (as in the case of the Finnish case study, aligning to an existing survey). Lessons from the application include:

1. Barriers to adaptation are part of socio-institutional processes and may be revealed and negotiated through social network analysis.

2. Capacity to adapt is the competence, or readiness, to act in socio-institutional processes. Neither the status of individual actors or relationships among actors are adequate indications of adaptive capacity per se since there can be an imbalance of power which diminishes capacity.

3. The drivers or determinants of adaptive capacity are far more complex in a stakeholder regime than the availability of information and finance. As yet, metrics of adaptive capacity lack this understanding of networks as drivers of change.

4. Adaptive networks can be described formally and this can also help to identify what outcomes different network configurations may produce.

5. Descriptions of both actors and networks can be related to qualitative metrics and used to benchmark progress towards outcomes. However, these are likely to be specific to the context of different networks and adaptation challenges.

6. Transformations in adaptive capacity are changes in actor-networks, including new institutional arrangements, new entities or new roles and responsibilities.

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For further information on the MEDIATION project: contact Rob Swart at
rob.swart@wur.nl

For further information on social network analysis, contact Sukaina Bharwani at
sukaina.bharwani@sei-international.org

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SEVENTH FRAMEWORK PROGRAMME

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