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## **Social network analysis as a tool for improved water governance in Malta**

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**Abstract:** Good water governance requires the participation of all stakeholders in the decision making process. Social network analysis (SNA) is a technique that permits the establishment of that stakeholder cohort which is considered to have an interest in the sector. Moreover, it demonstrates the nature and strength of stakeholder interactions to consolidate existing strong ties and develop weaker ones. Stakeholders having strong ties are considered to be influential whilst those having weak ties risk being isolated from contributing to a robust water governance framework. Stakeholders in the water sector can range from government-based entities to sector organisations and non-governmental organisations. When SNA was applied to the Maltese water sector it transpired that the sector is dominated by the more established actors. Worrying is the fact that, for example, agricultural organisations, despite the demand for water they exert, are still on the fringe of the water debate.

**Keywords:** water governance; social network analysis; stakeholder engagement; Malta.

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### **1 Introduction**

Malta is a small island, having an area of 316 km<sup>2</sup>, situated in the centre of the Mediterranean. With an annual rainfall of around 540 mm (Gatt, 1991), a population of 412,432 (NSO, 2014a) and an urbanisation rate of 20% (MEPA, 2008) Malta's freshwater resources are under considerable pressure.

Malta's potable water supply system relies on a mix of groundwater and desalinated water. In 2013, 13.8 Mm<sup>3</sup> of water were extracted from Malta's aquifers (NSO, 2014b) for potable water purposes. The National Statistics Office estimates that a further 19.1 Mm<sup>3</sup> of groundwater is extracted for agriculture (NSO, 2010). Thus, the total amount of groundwater abstracted may be estimated at around 33 Mm<sup>3</sup> when the sustainable yield has been estimated at 23 Mm<sup>3</sup> (Minister for Resources and Rural Affairs, 2009). Whilst all potable water is metered, groundwater abstracted from registered and non-registered boreholes is not charged. There are also a number of water distributors who sell abstracted groundwater to a range of economic operators and private individuals. This has resulted in a compromised groundwater quality and quantity (FAO, 2006) which goes against the Water Framework Directive (European Parliament and Council, 2000). Reversing such trends requires good water governance and a genuine effort to arrive at sustainable solutions in full consultation with interested stakeholders.

This paper reports part of a wider study related to the establishment of a robust water governance structure in Malta. Stakeholder involvement, has been identified as one of the key parameters for such a structure. In this context, this paper presents the outcome of the use of the Social Network Analysis technique in order to determine those stakeholders which are already active in the water sector and have strong ties with other relevant stakeholders. Moreover, it also attempts to characterise those stakeholders who are on the fringe of the sector and whose input is at risk as a result of their relative anonymity.

Social network analysis reflects the work of sociologists such as Georg Simmel and Émile Durkheim, who emphasised the importance of studying relationship patterns that connect groups of actors. Based on the concept of 'social networks', social scientists have used this principle since the 20th century in order to characterise relationships between subsets of social systems, at different hierarchical levels, from interpersonal to international.

## **2 Theoretical framework**

Water is a commodity that, to some degree, affects everyone be it in an economic, social or environmental manner. It is therefore a natural resource which cuts across a number of stakeholders who may have different interests. Social networks are key to build Society is made up of individuals who may also be represented by specific stakeholder organisations. Such groups have a higher critical mass in terms of their capacity to be more participative and communicative with the water authorities. This permits its membership's concerns to be factored into the decision making process. Some stakeholder organisations, albeit having a direct interest in water resources, may be absent and hence 'unknown' to the water authorities for whatever reason.

Such interests lead to a series of complex interactions between the different stakeholders and the sectors they represent. Understanding stakeholders has been criticised for lacking quality and consistency (Lienert et al., 2013) in terms of quantifying who plays an important role, what interests are at stake and how will decisions affect different stakeholders (Grimble and Wellard, 1997).

Good water governance requires stakeholder participation via effective channels that provide the most conducive medium for stakeholders to provide their opinions, constraints and reactions that can lead to an unprecedented level of societal inclusiveness (Bulkely, 2005; Biermann, 2007; Mirumachi and Van Wyk, 2010; Tortajada, 2010).

Although central authorities responsible for policy and program formulation are familiar with the main stakeholders they may genuinely overlook other relevant actors. The European Union has in fact stressed the importance of involving the public in decision-making as evidenced in the Aarhus Convention (United Nations, 1998), the 7th Environment Action Programme (European Parliament and the Council, 2013) and the Water Framework Directive (European Parliament and the Council, 2000).

It is only through appropriate participation strategies that inclusiveness may be enhanced. Singh et al. (2009) in fact argue in favour of inclusive water governance to be developed at a local level in order to be sensitive to the different problems that prevail amongst various sections of the community. Participation provides access to a voice in decision making to all either in a personal capacity or through sector representatives which will result in a constructive evolution in decision making as well as for decision makers to understand specific problems and for social groups to protect individual or group rights (Allan and Rieu-Clark, 2010). Effective participation results in taking true cognisance of stakeholder views as well as to secure ownership (Rouse, 2007).

A direct measure of the level of participation of stakeholders with central authorities is difficult to find. SNA can reveal the pattern of relationships and is a means of determining the influence of stakeholders on decision making (Yang et al., 2011). It is based on the notion that relationships amongst stakeholders are an important (Wasserman and Faust, 1994) and can be used as a measure of participation. This will allow weaker ties to be shored up contributing to a strengthened water governance framework. Reed et al. (2009) argue that in modern day policy making, public participation is becoming an inherent step. Consequently, decision-makers constantly seek to understand who is affected by decisions and actions taken whilst identifying power brokers. SNA can assist decision makers to chart the 'pull' and 'push' factors of stakeholders to make informed choices on who and what to prioritise as part of the decision making process. Networking involves a set of informal ties that lead to decision-making understandings that include non-state actors (Adam and Kriesi, 2007). In fact the approach in water policy related studies has been to consider the network in terms of the cross-sectoral and transboundary nature of the different actors in the sector (Ingold et al., 2010; Lubell and Fulton, 2007). SNA is thought to be able to identify the structural aspect of actor networks thereby going beyond traditional institutional settings (Scholz and Wang, 2006). It is particularly relevant for the water sector due to the fact that the sphere of influence goes beyond hierarchical and centralised decision-making (Ostrom, 1990; Pretty and Ward, 2001).

Lennox et al. (2011) in their New Zealand case study, concluded that stakeholder participation in decision-making is beneficial and increasingly necessary to resolve governance related problems and tensions around the of Canterbury's water resources even though one is faced with practical and systemic barriers that must be overcome to realise the full potential of such participation. Similarly, Demetropoulou (2010) demonstrated that in the implementation of the WFD in Greece, the use of an encompassing approach in the selection of participants. As opposed to previously exclusive practices that dominated Greek policymaking, was influential in institutionalising networking and a greater involvement of stakeholders and the public. Akhmouch and Kauffmann (2013) conclude that the involvement of the private sector has uncovered gaps in water governance which need to be addressed in order to improve water governance. However, one must acknowledge that the involvement of the public sector is often viewed with suspicion (Dellas, 2011) particularly in a sector such as that

for water resources where the commodity is seen to be essential for life. Notwithstanding, it is important to be able to involve both extremities of the stakeholder ladder without allowing one to overshadow the other. Interestingly, Garande and Dagg (2005) bring to the fore the concept of participation in rural areas. Although Malta does not have comparable rural areas, owing to its small size and state of development, it can mirror certain characteristics found in introverted communities such as those involved in agriculture. Often enough such communities do not come to the fore of water debates yet their impact is of a great magnitude. In the case of rural Chile, it emerged that top-down approaches had to be replaced with bottom-up strategies contributing towards the empowerment of such communities (Garande and Dagg, 2005). The common message is one which advocates collaboration between different actors to respond to emerging and acute needs. This generates social capital through increased social cohesion with a view to cooperate and find solutions even in the face of difficulties in flow of information (Borg et al., 2015).

SNA can play a valuable role in evaluating the pattern of 'whole-of system' stakeholder relationships (Yang et al., 2011), a level which is considered to be of fundamental importance when understanding relationships for governance purposes. Reed et al. (2009, p.1933) define stakeholder analysis as "a process that: i) defines aspects of a social and natural phenomenon affected by a decision or action; ii) identifies individuals, groups and organisations who are affected by or can affect those parts of the phenomenon (this may include nonhuman and non-living entities and future generations); and iii) prioritises these individuals and groups for involvement in the decision-making process". In fact SNA has also become popular amongst policy-makers, regulators and governmental organisations (Friedman and Miles, 2006) who are key towards securing robust governance frameworks. In fact Lienert et al. (2013) in their study on the water infrastructure planning process demonstrated that linking a stakeholder analysis with social network analysis is very fruitful and generates complementary results. Similarly, Stein et al. (2011) have also shown that SNA can be applied successfully in analysing water governance frameworks in Tanzania.

In this context it is thought that Malta, being a very small country, should possess a more intense informal network due to the intimacy between stakeholders that characterises closely knit communities. At the same time, the ease of access to politicians and senior administrators can lead to direct relationships between the authority and the individual actor, at the expense of the fostering of ties amongst the different actors involved. Malta's policy making relies heavily on public consultation, with online consultations gaining increased popularity. Meaningful consultation involves the gaining of a holistic understanding of the position of all stakeholders with a view to craft a framework that maximises actor goals. Relying on methods that require literacy, resource or oral skills may marginalise certain actors. Good water governance requires the identification of all possible stakeholders and reaching out to them in order to ensure that all views are captured. SNA not only helps in identifying the suite of actors but also sheds light on those who are more influential and those who are on the fringe, both of which may require different strategic approaches to bring them on board.

### 3 Methodology

As Malta is a small country where sectorial overview may be achieved rather easily, an initial set of potential stakeholders in the water sector was identified from the author's own personal experience. This list was subsequently discussed with the water policy department and the water service provider in order to add further stakeholders that these key entities might have identified over and above the initial list. This was on the basis that the policy and program leaders in the water sector were deemed to be able to provide the best insight into refining a first-cut list of stakeholders. It must be borne in mind that water resources management and operations are very much centralised in Malta creating a dependency for any action with these government stakeholders. This makes them ideal reference points to amplify the initial set of actors identified by the author. This first list of actors was circulated amongst them where each actor was asked to rank the other identified actors in terms of the strength of any relationship that existed between the two organisations. Each actor was also allowed to add other stakeholders that were considered, on their part, to have an interest in the water sector. This with a view to ensuring that a holistic network could be established without omitting any potential contributors. Newly identified actors were included in the list of potential actors but were assumed not to have any relationship with those who did not mention them at all. In general, most of the stakeholders responded within a reasonable period of time. Those who did not respond were contacted electronically or by phone and asked to complete the survey or else the survey was conducted there and then *viva voce*.

An initial list of 21 stakeholders was developed and a survey was undertaken amongst them in order to determine the relationship between themselves as well as with other water-related stakeholders not included in the original list. This led to an increased dataset of 32 stakeholders. The 32 stakeholders were coded for ease of reference as follows:

**Table 1** List of stakeholders (see online version for colours)

<i>Code</i>	<i>Stakeholder</i>	<i>Code</i>	<i>Stakeholder</i>
1	Ministry for Water (MECW)	17	Chamber of Commerce (Chamber)
2	Malta Resources Authority (MRA)	18	Ta' Qali Producers Group
3	Water Services Corporation (WSC)	19	Mgarr Farmers Coop
4	MEPA (Environment)	20	Koperattiva Rurali Manikata
5	MEPA (Development)	21	Gozitano
6	Works Division (Valley Management)	22	Chamber of Engineers (CoE)
7	Works Division (Buildings Regulations Office)	23	Chamber of Architects (KTP)
8	Ministry for Gozo (Eco Gozo)	24	Managing Authority Rural Development
9	University of Malta	25	Paying Agency Rural Development
10	Transport Malta	26	Plant Health Directorate
11	Malta Water Association	27	MCAST

Notes: ■ Agricultural organisations; ■ Government entities; ■ Professional bodies; ■ Business representatives; ■ e-NGO.

**Table 1** List of stakeholders (continued) (see online version for colours)

<i>Code</i>	<i>Stakeholder</i>	<i>Code</i>	<i>Stakeholder</i>
12	Environmental Health Division	28	Local Councils Association
13	Rural Development Department (RDP)	29	Malta Enterprise
14	Malta Business Bureau (MBB)	30	Malta Tourism Authority
15	MHRA	31	KIM
16	GRTU	32	KPH

Notes: ■ Agricultural organisations; ■ Government entities; ■ Professional bodies; ■ Business representatives; ■ e-NGO.

As the main focus of the research was to map the water stakeholder network in terms of the links that existed between the various stakeholders, each response of an actor's involvement with an other actor, or otherwise, was cascaded into a binary format (0 = no relationship, 1 = relationship). Although data on the intensity of the relationship was also collected by allowing respondents to express the intensity of their relationship on a scale from (1–3), it is beyond the scope of this research to analyse intensity before establishing the basic criteria of the network itself.

Analysis was carried out using UCINET 6 (Borgatti et al., 2002) which captures the interactions between stakeholders in binary format. Specific matrix manipulations yield quantitative values that characterise the dynamics of the network of stakeholders. As a network consists of a binary representation as to whether A considers to have a relationship and vice versa, then the resultant matrix is always a square matrix. Moreover in the case of the water network, the data is of a directed nature meaning that whilst A may consider to have a relationship with B the converse might not apply, i.e., B does not consider itself as having a relationship with A. Network data are defined by actors and by relations or nodes and ties.

The aim of the SNA was to identify:

- the main stakeholders that formed the 'water network' and who's inclusion could contribute towards increased communication between central authorities and stakeholders
- any gaps that may exist between the central authorities and certain stakeholders with a view to bring 'fringe' stakeholders into a more mainstream position
- those stakeholders who appear to have the greatest 'pull' factor.

These aims were consonant with the governance aim of securing full stakeholder participation. For this to occur, it is imperative that the suite of stakeholders is identified and to subsequently establish whether they are integrated into the 'water sector' or whether a more proactive approach from the centre is required. The views of the principal stakeholders on Malta's water governance structure were subsequently obtained through a separate survey intended to explore water governance from a stakeholder perspective in more depth as well as to complement a parallel national survey on water governance amongst the Maltese population.

## **4 Results**

### *4.1 Stakeholder relevance*

Network cohesion was assessed through the following parameters:

- density: the total number of ties divided by the total number of possible ties
- degree: as the network data is non-symmetric, the in-degree of a vertex A is the number of ties received by A and the out-degree is the number of ties initiated by A
- a univariate analysis of rows and columns: analysis rows and columns separately and hence give a measure of actor's incoming and outgoing ties
- reachability: the length of the shortest path between two nodes/actors indicating a stronger tie between two nodes
- reciprocity: the amount of ties that are reciprocated in a network
- transitivity: reflects the notion that if A and B are friends and B and C are friends then it is likely that A will befriend C
- geodesic distance: measures how easily information may flow from one actor to another without encountering bottlenecks
- maximum flow – measures the level of connectedness by establishing how many different actors in the network lead to a particular target.

Considering two actors A and B, an outward tie is a claim by A that a relationship with B exists. On the other hand, an inward tie would mean that B claims that an existing relationship exists with A. Hence the matrix of sending and receiving ties may be asymmetric as if A claims a relationship with B does not imply that B agrees that such a relationship exists with A.

The highest sender is the Rural Development Department which is responsible for the development of the agricultural sector. Agriculture, as a sector, is estimated to withdraw 19Mm<sup>3</sup> of groundwater annually and therefore has an inherent mission to address water resource issues within the sector. However, this actor features at a lower level where receiving ties are concerned and is ranked joint 8th. This may also be due to the fact that this entity suggested other rural related actors affected by water issues when in fact they are not. It also confirms that the actors in the water network go well beyond the agricultural sector.

The Malta Resources Authority (MRA), the water sector regulator, is the highest receiver indicating the respect and influence it commands within the sector. Although ranking a modest 5th in terms of outgoing ties, the balance between incoming and outgoing ties confirms its strong influence. Notwithstanding, its 20 inward and 12 outward ties still represent only 64.5% and 61% of the possible connections with identified actors. Although the relevance of certain identified actors to the water network is questionable, even by their very own admission of not having any ties in respect of water issues, it still points towards a water network which still needs to develop further in order to reach other actors. Similarly, the Water Services Corporation (WSC), the state-owned water utility, features high on both outgoing (3rd) and incoming (2nd) ties. The WSC being the only provider of water and sewerage services in Malta and having

been established long before its regulator is synonymous with the water sector. The Ministry for Water (MECW) is also high on incoming (7th) and outgoing (5th) ties.

State entities, demonstrate their strong influence which is the result of proximity between actors, the monopolistic situation in the provision of water services and the importance the political class are seen to have in decision making. Notwithstanding, it is evident that these key actor ties cover less than half of the identified actors which may reflect a silo mentality which mitigates against joined-up government. This implies that the water network continues to evolve and has not yet extended itself to a reach that meets all stakeholders. This may lead to information gaps which could imply that government authorities are not fully informed of stakeholder needs or the reverse where stakeholders are not aware of the national problem and the mitigation requirements.

Both arms of the Malta Environment and Planning Authority (MEPA) – the development control and environment protection regulator – feature high both on outgoing and incoming ties ranking 6th and 8th on outgoing ties and 4th and 3rd on incoming ties respectively.

The Malta Chamber of Commerce and Industry (Chamber) and the Malta Hotels and Restaurants Association (MHRA) are the social partners who have obtained the highest ranking from the non-government organisations. These two entities have secured 15 and 11 outgoing ties and 10 and 12 inward connections respectively. The recognition of the importance stakeholders may stem from a number of factors not least the:

- recognition that water has an economic value which effects industry
- recognition that hotels can have high water demands and that constructive action can be taken through collaboration with the MHRA
- result of a Life+ project in which the Chamber and MHRA are partners in a water conservation project together with the Malta Business Bureau which received 10 and may be a recognition of their visibility in working on a specific water-related project.

Farmer organisations, both agricultural and animal husbandry, feature lowly on the ranking of influence for each identified actor. Two of the three agricultural organisations, in fact, do not have any outgoing ties indicating that they do not see themselves as being relevant to the water sector. One of them receives five incoming ties whilst the other two receive between 1 and 2 demonstrating that such organisations are viewed with little importance despite the agricultural sector being identified as a high abstractor of groundwater. The same may be said of the two animal husbandry organisations who have 2–3 outgoing ties but only 1 incoming tie. Despite their potential impact on sewage quality and volumes they seem to be distant from integrating themselves within the water network and are kept at arm's length by the network itself. The network diagram for the water sector is shown in Figure 1 and reflects those actors having the most incoming and outgoing ties as they are positioned towards the centre of the network diagram as shown by the inner red circle encompassing stakeholders 1 (Ministry), 2 (MRA), 3 (WSC), 4 (MEPA-ENV), 5 (MEPA-DEV), 9 (UoM), 13 (RDP), 17 (Chamber). This already gives a fair idea of the most influential stakeholders within the water network.



deviation is 0.426 implying high variability, i.e., that there are groups within the network who form nested collaborative alliances amongst them.

### 4.3 Degree

The data for the water network is asymmetric and therefore there is merit in analysing the ties being sent and ties being received separately. For non-symmetric data the in-degree of a vertex  $u$  is the number of ties received by  $u$  and the out-degree is the number of ties initiated by  $u$ . For a given binary network with vertices  $v_1 \dots v_n$  and maximum degree centrality  $c_{\max}$ , the network degree centralisation measure is  $\sum (c_{\max} - c(v_i))$  divided by the maximum value possible, where  $c(v_i)$  is the degree centrality of vertex  $v_i$  (Hanneman, 2001). The out-degree is a measure of how influential an actor may be whilst the in-degree is usually associated with power. Power relates to how dependent actors are on a particular actor whilst influence relates to the ability to transmit one's opinion in the most effective and credible way to as many different audiences as possible. The normalised values evidence a degree of fragmentation within the network shown by a tailoring-off of the actors' outward and inward ties. Such tailoring-off ranges from 74.19% for the out-degree and 64.52% for the in-degree to nil. In the out-degree, the highest value is that of 74.19% which drops off rapidly to 48.39% for the second highest value indicating a significant gap, and hence drop. For the in-degree, the second highest value is that of 58.07% which represent a milder drop although it subsequently falls at a steady rate. The routine indicates a Network Centralisation (Out-degree) of 51.93% and a Network Centralisation (In-degree) of 41.94%. On average each actor has a degree of 7.41 which is low compared to the 32 actors involved. The coefficient of variation for the out-degree is 72% whilst that for the in-degree is 82%, percentages that are very high degrees and which could point towards the existence of fringe actors. Such a disaggregation is also supported by the network centralisation values.

### 4.4. Univariate analysis on rows and columns

In an asymmetric network, a separate analysis of the ties being sent and received can be undertaken to establish the differences between actors' 'sending' and 'receiving' ties. This demonstrates how actors are embedded in the overall network density. This procedure computes mean, standard deviation, variance, Euclidean norm, maximum, minimum and total number of observations for each row or column of a matrix, or for the matrix taken as a whole. The RDP has the highest mean but not the highest variance, implying that despite a high number of outgoing ties, its strength is to a certain extent somewhat limited. It can highlight those actors who are on the fringes of the network such as the Ta' Qali Producers Group (Actor 18) and Mgarr Farmers Co-op (Actor19) who happen to be farmer organisations. This is of concern as a substantial part of Malta's over abstraction of groundwater results from the agricultural sector. It is therefore important for the competent authorities to realise these stakeholders' detachment and work towards further integrating them within the water network to lower their impact on freshwater resources. This thematic recurs across the agricultural sector showing how poorly integrated the agricultural and the animal husbandry sectors are within the wider water network. Hence, one cannot imagine how such organisations declare that they have no links altogether or how such links are so weak.

When the univariate routine is applied to columns it shows the spread that exists in incoming ties. The mean and standard deviation do not reflect any different trends. From the mean one can also understand the dilution that exists between connected and unconnected actors confirming previous parameters' indications on the level of disaggregation of the network. When analysing columns there is a certain increased degree of significance as these ties are ones which have been directed by others towards the selected actors and therefore have a bearing on the rating of those actors which have a higher relevance and influence than others. This analysis demonstrates the same trends but with added significance as these ties do not depend on the actor's choice but on whether other actors feel they are connected to a particular actor. The agricultural and animal husbandry stakeholders are again conspicuous by their low score but other stakeholders such as the professional bodies for architects and engineers are also not considered to be relevant to the water sector. Similarly, low scores are observed for the Managing Authority and Paying Agency responsible for rural development. The former is of particular concern as although the Operational Programme for Rural Development could contain water as an eligible action, the stakeholder itself is not seen to be relevant by other stakeholders in the sector. This could mean that funds that could be available for water related actions in the agricultural sector remain unknown or untapped.

Having run the univariate routines, a comparison of the means assists to further determine those actors which are predominantly senders and those who are predominantly receivers. Having sorted the actors in descending order of difference between the means of rows and columns implies that as an actor moves from a positive to a negative value, the position shifts from a net sender to a net receiver. Of the most influential actors, only the RDP and Chamber are net senders whilst the rest are net receivers. Being a net receiver has the added value of further highlighting the relevance, influence and potentially power that the particular actor can exert, hence the inclusion of the Ministry responsible for water resources, the water regulators and the water service provider.

#### *4.5 Reachability*

Reachability measures the extent with which the flow of information can reach all stakeholders. The reachability routine constructs a matrix of reachability values for every pair of nodes which represents the value of an optimum path. The algorithm produces a value in row *i*, col *j* of a matrix if node *j* is reachable from node *i* and a blank otherwise (Borgatti et al., 2002). An actor is 'reachable' by another if there exists any set of connections by which we can trace from the source to the target actor, regardless of how many others fall between them (Hanneman, 2001). If it is not possible for all actors to reach all other actors then the network can be divided into two or more groups. This has a bearing on the ease to achieve cohesiveness amongst a network of stakeholders. Stakeholders that are cut off from a group cannot be reached, influenced or educated. This notion is of particular importance for competent authorities so as to identify outliers and secure their integration. For Malta's water network it was established that:

- no one connects to the Chamber of Architects
- the Ta Qali Producers group, Mgarr Farmers and Plant Health do not connect to anyone.

The Plant Health Department's absence is not of concern. The KTP represents warranted architects and civil engineers. Within the degree program, upcoming architects and civil engineers have the opportunity to follow a number of credits related to water resources and their management. However, as a Chamber, it has focused on the development aspect of the profession's portfolio and has done little, if at all, to cover the civil engineering aspect of water resources. Hence it comes as no surprise that it does not receive any connections or is considered relevant to the water sector. The concern related to the farmer organisations has been discussed earlier and is reiterated herewith, reflecting a serious shortcoming in the light of the sector's high groundwater abstraction volumes.

#### 4.6 *Reciprocity*

Reciprocity is mainly underpinned by the fact that a reciprocated tie evidences a relationship between the two actors. Once a relationship exists, then one can realistically plan as to how to build upon such relationships in order to mainstream water sector objectives, good practices and education across the entire water network. Reciprocity, whether in matching an incoming tie or in confirming that there is no relationship between any two actors, gives a reinforcing measure of the network's pairs. The dyads ( $i, j$ ) in this sociometric choice matrix  $X$  can be classified as asymmetric ( $x_{ij}$  not equal to  $x_{ji}$ ) and are modelled as  $a_{ij} = \lambda_{ij} \exp(\theta + \alpha_i + \beta_j)$  (Borgatti et al., 2002).

The network is characterised by a dyad-based reciprocity of 0.32 meaning that for any two stakeholders, chosen at random, there is a probability of 0.32 that there exists a reciprocal relationship. This means that only 32% of the actors in the water network have a reciprocated connection and therefore the basis from which to depart to take advantage of already established relationships is a low one (compared to full reciprocity at 100%) upon which more work needs to ensue to increase the amount of relationships between actors within the water network. Given that this figure is low in percentage terms also evidences a lack of cohesion amongst the key players within the water sector. From a governance perspective such a disaggregated network cannot positively contribute to effective participation, communication and inclusiveness as their some actors who are not recognised by others as forming an inherent part of the network. This because there exists a very weak relationship between certain stakeholders, if any, and which does not permit a full integration of stakeholders in the formal and informal discussions that are required for a more robust water network which can lead to a more sustainable management of water resources.

A more detailed analysis is provided in order to elicit further trends on the behavioural aspects of some of the key actors.

##### 4.6.1 *Symmetric*

Symmetric is low with MRA having the highest score at 0.60. MRAs reciprocity is the highest in significance as it has total of 32 ties. This shows that MRA is gradually becoming the point of reference for water related issues. It is subsequently followed by the Chamber (0.56) and the MBB (0.55). The latter two organisations have already been discussed earlier in the context of the Life+ program with a water focus they are currently benefitting from. However, more importantly, the MBB is founded by the Chamber and the MHRA and hence one expects an intimate relationship between these three actors.

#### 4.6.2 Out non-symmetrical results

A score of 1 implies that the number of non-symmetric outgoing ties is equal to the total number of non-symmetric ties. Hence in the case of Actor 13 (Rural Development Department), for example, the 11 receiving (incoming) ties have been balanced and the actor has more sending outcomes over and above those reciprocated. Similarly, Actor 17 (Malta Chamber) has a high return of reciprocity albeit being a net sender. Notwithstanding, the RDP have a sender/receiver ratio of 2.1 as opposed to that of Malta Chamber's 1.5. Hence, the significance of the latter is enhanced as it has a higher relevance in respect of managing to gather a higher ratio of incoming ties.

#### 4.6.3 Incoming non-symmetrical

Of significance here are the scores obtained by the MRA which continues to confirm the trait that it seems to be recognised as the leading player in the water sector. However, due note is to be taken of the Eco-Gozo, University and MBB. MBBs score may be attributed to its current implementation of a Life+ project on water conservation. This demonstrates that activity in the sector tends to raise organisational profile and hence relevance. The Ministry for Gozo, through its Eco-Gozo department, can also be identified as a relevant player. This stems also from a Gozo-wide exercise to retrofit households with water conservation devices as well as efforts to clean valleys in order to permit higher water storage volumes to be created. The university is also a well-respected institution which is sought after for its individual expertise as well as its corporate gravitas. Of interest is the score that was obtained by the Malta Water Association (MWA) which has a low number of outgoing ties but has ten indicated incoming ties which goes to show that it is also becoming relevant within the water network. To a certain extent this could also be said of the Valley Management Unit which perhaps needs to realise that it has to interact with more stakeholders for there are an appreciable number of stakeholders who see this actor's increased integration within the water network owing to the water related work it does to make valleys have a greater capacity to store water and to promote recharge. The scores obtained by those actors exceed a value of 0.8 are summarised in Table 2. Mixed feelings exist as regards the role of the Building Control Office (BRO), which also seems to be recognised as a relevant player much more by others than by itself. Buildings are a source of transformation of virgin sites to impermeable ones, from a water perspective. Moreover, buildings are in themselves a source of water use. As such buildings need to be water friendly both through the harvesting and reuse of stormwater generated therefrom as well as in terms of the water fitting standards that are to be allowed in buildings to make them as water efficient as possible.

**Table 2** Incoming non-symmetrical results ( $n > 0.80$ )

<i>Actor</i>	<i>Score</i>	<i>Sender</i>	<i>Receiver</i>	<i>Significance</i>
18	1.00	0	1	
19	1.00	0	5	
26	1.00	0	1	
21	1.00	2	4	
2	1.00	12	20	<i>Most significant</i>
11	0.91	1	10	<b>Potentially significant</b>

**Table 2** Incoming non-symmetrical results ( $n > 0.80$ ) (continued)

<i>Actor</i>	<i>Score</i>	<i>Sender</i>	<i>Receiver</i>	<i>Significance</i>
6	0.89	2	9	<b>Potentially significant</b>
7	0.88	1	7	<b>Potentially significant</b>
8	0.86	5	10	<i>Most significant</i>
9	0.80	8	14	<i>Most significant</i>
14	0.80	7	10	<i>Most significant</i>

#### 4.6.4 *Outgoing symmetric*

The results for outgoing symmetric in Table 3 once again bring to the fore the same organisations that were deemed relevant in the incoming non-symmetrical. These are the MRA, MBB and Eco-Gozo which see the highest percentage of their outgoing ties being reciprocated. This shows a mutual recognition of organisational involvement in the water sector.

**Table 3** UCINETs outgoing symmetric results ( $n > 0.80$ )

<i>Actor</i>	<i>Score</i>	<i>Sender</i>	<i>Receiver</i>	<i>Significance</i>
21	1.00	2	4	
2	1.00	12	20	<i>Most significant</i>
14	0.86	7	10	<i>Most significant</i>
8	0.80	5	10	<i>Most significant</i>

#### 4.6.5 *Incoming symmetric*

Table 4 summarises the scores for those actors having  $n > 0.8$  in the incoming symmetric parameter. In this case, the actors who are seen to reciprocate incoming ties change. Of significance are the RDP which, however, may have seemed to overestimate its outgoing links and Chamber. This further dovetail with their position as net senders identified earlier. On the other hand all the other actors have just one incoming tie which makes any analysis pointless.

**Table 4** UCINETs incoming symmetric results ( $n > 0.80$ )

<i>Actor</i>	<i>Score</i>	<i>Sender</i>	<i>Receiver</i>	<i>Significance</i>
32	1.00	2	1	
13	1.00	23	11	<i>Most significant</i>
31	1.00	3	1	
22	1.00	6	1	
27	1.00	7	1	
24	1.00	11	1	
29	1.00	14	1	
17	0.90	15	10	<i>Most significant</i>

#### 4.7 *Transitivity*

Transitivity measures the concept that a friend of an individual's friend is also that individual's friend. High transitivity in a network makes it have a clumpy structure having knots of nodes which are interrelated. Three vertices  $u$ ,  $v$ ,  $w$  taken from a directed graph are transitive if whenever vertex  $u$  is connected to vertex  $v$  and vertex  $v$  is connected to vertex  $w$  then vertex  $u$  is connected to vertex  $w$ . The density of transitive triples is the number of triples which are transitive divided by the number of paths of length 2, i.e., the number of triples which have the potential to be transitive (Borgatti et al., 2013). Applying the UCINET transitivity routine to the water network yielded a network transitivity of 22.91%. This is very low, in percentage terms, and may indicate that the theory of transitivity may not apply to this network. This may be due, for example, to individual facets of interest in the water sector which are not shared by others and which therefore do not create common platforms of interest. Although this could exist in part, one has to consider the fact that Malta's size is rather small and hence 'friend of a friend' affiliations are easier to form. It could also reflect an egocentric approach to collaboration or problem solving limiting the number of actors to avoid contestations, sharing of information or any form of collaboration. It could also mean that the agenda is driven by personal or institutional singular interests.

#### 4.8 *Geodesic distance*

Geodesic distance measures the distance between actors in a network that is the shortest distance between two actors. In the water network, geodesic distances are considered to be relatively small averaging 2 and with a standard deviation of 0.7. This means that the actors are relatively close to each other and that information can flow and reach each actor quite easily. 42.8% of actors are at a distance of 2 from each other with those on either side of it, i.e., 1 and 3 distances away amount to 23.9% and 20.5% respectively. The RDP is the only entities to have an eccentricity of 2 which implies that they are those who are closest to the various actors.

#### 4.9 *Maximum flow*

Another measure of the cohesion of the network can be established through the maximum flow parameter. This parameter gives a measure of the level of connectedness between two actors in a network by establishing how many different actors in the neighbourhood of a source lead to pathways to a target (Hanneman, 2001).

The actors which demonstrate to have the highest number of paths to convey their message are those which have at least 8 pathways and which represent 25% of all actors within the network. These are:

- Government-based – MECW, MRA, WSC, MEPA PI and Env, TM, Env Health, RDP, MA (Rural), PA (Rural), ME, MTA.
- Academic – University of Malta (UoM).
- NGOs/Social Partners – MHRA, Chamber.

The MBB and MCAST are considered borderline at seven paths. In this sense one cannot discard their relevance altogether. Previous parameters have indicated the potential of the MBB. However, it is the first time that MCAST comes forward. This institution was set up with the purpose of offering vocational education and hence technician-type training. The water sector presents a number of opportunities for such training. Moreover, MCAST today offers even first degrees and hence has increased its sphere of influence within the educational dimension.

#### *4.10 Centrality and power*

In any network it is likely to find actors assuming a leading or following role – those who exert power and those who are more submissive. Being central to a network means that a number of other actors have a direct link or a dependency and hence a central position can result in actor power. In attempting to characterise the centrality and power traits within the asymmetric water network, two tests have been undertaken namely that of betweenness and of flow centrality.

##### *4.10.1 Betweenness*

Betweenness measures the frequency with which a particular node falls in between the path which connects two actors. The higher the value, the higher the potential for exerting a controlling, or gatekeeping, influence on the flow of information between one actor and another. Some interesting results emerge in that the WSC seems to be the most powerful actor (18.62%). On the same level is also the RDP (18.60%). On the other hand, the regulatory entities namely MRA and MEPA (Env), albeit in 3rd and 4th place, have a normalised betweenness of 8.18% and 7.62% respectively. The Ministry also ranks lowly in 7th place (4.64%) possibly as it is a newly former Ministry. The results show that there is some variation in actor betweenness with a standard deviation of 4.69 compared to a mean of 2.85 (nBetweenness). The network has a Network Centralisation Index of 16.28% which is low and which points to a situation where most connections can be done without the need of an intermediary. This seems to make sense in a small country like Malta where people tend to know each other more and can hence approach each other directly.

##### *4.10.2 Flow centrality*

Flow betweenness centrality builds upon the previous routine with the variation that allows for those paths which actors can access to reach other actors but through different paths, other than the shortest distance, to bypass potential obstructions. This results in a higher mean (3.20) and lower standard deviation (4.48) as well as a Network Centralisation Index of 17.45%. The output confirms the previous conclusions in that RDP and WSC are reconfirmed as net leaders with RDP (20.10%) this time gaining a higher percentage than WSC (16.80). Whilst the MRA (7.93%) remains in 3rd place and at a distance from the first two, it is followed by a new player, this time the Environmental Health Division (6.01%) which now precedes MEPA (Env) (5.35%). Thus whilst this analysis reconfirms the ease of accessibility of each actor, it also brings forward Environmental Health as a potential new broker.

### 4.11 Cliques

It is only natural for special relationships and more intensive sub-groups to be formed within any network or organisations or people. Such sub-groups may lead to the formation of semi-independent workings within the network. By identifying such cohesive subgroups within a network one could possibly try to understand better why such subgroups are formed and more importantly why they work. The clique routine on the water network returned the cliques as illustrated in Table 5:

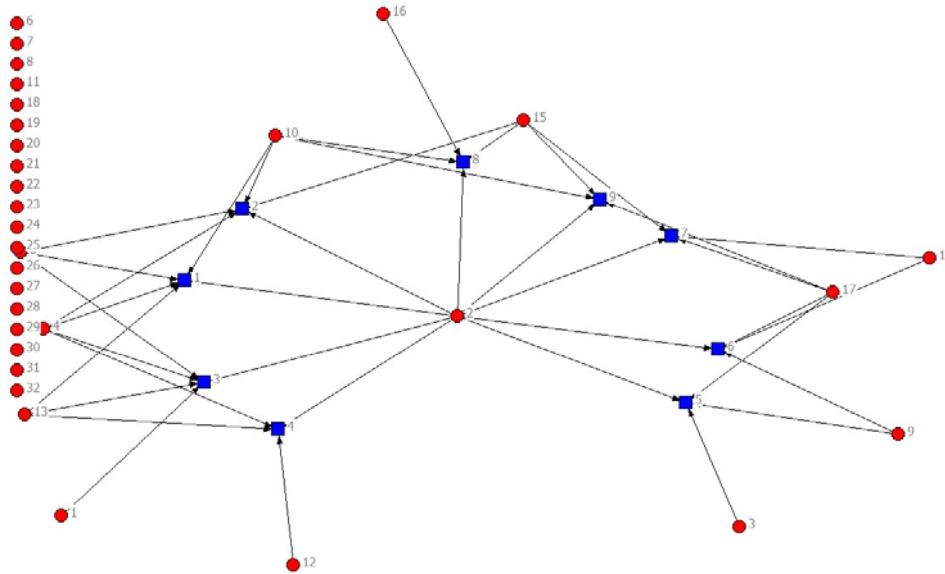
**Table 5** Clique co-membership matrix (extract) (see online version for colours)

Clique	Actors						
1	MRA		MEPA-ENV	MEPA-DEV	TM	RDP	
2	MRA		MEPA-ENV	MEPA-DEV	TM	MHRA	
3	MRA		MEPA-ENV	MEPA-DEV	MECW	RDP	
4	MRA		MEPA-ENV	ENV-HLTH		RDP	
5	MRA	CHAMBER		WSC		UoM	
6	MRA			WSC	MECW		
7	MRA	CHAMBER				UoM	MBB
8	MRA			MEPA-DEV		UoM	
9	MRA	CHAMBER				MHRA	MBB
10	MRA				MECW		MBB
11	MRA				TM	MHRA	GRTU
12	MRA			ENV-HLTH			GRTU
13	MRA	CHAMBER			TM	MHRA	
14	MRA	CHAMBER		ENV-HLTH			
15			ECO-GOZO		MECW	RDP	
16		CHAMBER		ENV-HLTH		MTA	

The MRA evidences a strong position in the above matrix of identified cliques in that it is present in 14 out of 16 cliques (87.5%) with the Chamber of Commerce and Industry following suit and present in 6 cliques (37.5%). However, 16 cliques when 32 actors are present is considered too high and therefore if the Clique routine was limited to require that the minimum number of actors per clique to 4, the number of cliques would be reduced to 9.

**Table 6** Clique co-membership matrix (extract) (see online version for colours)

Clique	Actors						
1	MRA		MEPA-ENV	MEPA-DEV	TM	RDP	
2	MRA		MEPA-ENV	MEPA-DEV	TM	MHRA	
3	MRA		MEPA-ENV	MEPA-DEV	MECW	RDP	
4	MRA		MEPA-ENV	ENV-HLTH		RDP	
5	MRA	CHAMBER		WSC		UoM	
7	MRA	CHAMBER				UoM	MBB
9	MRA	CHAMBER				MHRA	MBB
11	MRA				TM	MHRA	GRTU
13	MRA	CHAMBER			TM	MHRA	

**Figure 3** Actors and cliques ( $n > 4$ ) (see online version for colours)

Such a manipulation and as illustrated in Table 6 brings to the fore the universality of MRAs membership in each clique. Furthermore, Figure 3 shows that:

- actors 6 (Valley Management), 7 (Building Regulations Office), 11 (MWA) and 18–32 (farmer organisations, rural development organisations, MCAST, Local Councils Association, Malta Enterprise and Malta Tourism Authority) are isolates
- as clique membership increases from a minimum of 3 to 4 members, Actor 8 (Ministry for Gozo) becomes an isolate
- when clique membership is set at a minimum of 3, Actors 2 (MRA) and 17 (Chamber) seem the most closest
- MRA nearly overlaps with all actors when membership is set at a minimum of 3 and with all when membership is set at a minimum of 4
- actor 2 (MRA) and Actor 17 (Chamber) are the closest when membership is set at a minimum of 3
- as membership is increased to a minimum of 4 actors, Actor 2 (MRA) relates closest to Actors 4 (MEPA-ENV), 10 (Transport Malta), 15 (MHRA) and 17 (Chamber).

This analysis shows that the MRA emerges as the strongest actor in the water network. As at the time of writing, the MRA has shed some of its resources for a Water Policy function to be formed within the Ministry. Time will tell whether there will be a growth in the influence of the Ministry at the expense of the MRA. Notwithstanding, as the membership tightens, one notes that MRAs closest relationships are with:

- MEPAs Environment Directorate, reflecting the intimacy in nature of water as a resource as well as a source of environmental maintenance and generation. This is also confirmed by the fact the two entities are designated competent authorities for the implementation of the resource and environmental aspects of the WFD.
- Transport Malta, possibly in the light of the synergies that may exist with its management of stormwater runoff from roads.
- MHRA and Chamber, who under the stewardship of the MBB (which is co-owned by these two entities) are currently implementing a Life+ project on water conservation in industry and tourism establishments and which seems to have created this 'network'.

It is of course of concern to note that various analytical techniques continue to confirm the remoteness from the centre of the network of the rural development players particularly in the light of their impact on water resource volumes and the proposed regulation proposed thereto. One also notes that further integration of the academic institutions needs to be in place with such institutions being the natural port of call of the water network stakeholders for capacity building purposes. One also notes the growing yet limited influence of the e-NGO focusing on water resource matters.

Hierarchical clustering of the clique overlap matrix, shown in Figure 2, shows the clique network diagram as it develops. Actors 2 (MRA) and 17 (Chamber) are joined at Level 5 which is indicative of the 5 cliques in which they are present. At level 3, that is where actors are present in 3 cliques, these actors are joined by Actors 4 and 5 (MEPA Environment and Development), Actor 10 (Transport Malta) and Actor 15 (MHRA). As the level drops other actors come into an extended grouping. Notwithstanding, at the higher levels, the most influential actors appear together.

## **5 Discussion**

Social network analysis was one of a set of tools used to better understand the current water governance framework in Malta. It forms part of a wider study which looked at other governance aspects. The importance of participation for robust governance has been elicited many a time (United Nations Development Programme, 1997; Varis and Tortajada, 2009; Tortajada, 2010; Allan and Rieu-Clark, 2010). To date there has been no real study in order to identify how stakeholders interact with each other in Malta with consultations often relying on singular rather than integrated forms of participation. From the preceding analysis it is clear from both the cohesion and centrality routines that the water network is still evolving and is far from being in a consolidated format where stakeholders are well connected to each other and information can flow freely amongst them in both directions. In fact even those actors having a high number of incoming or outgoing ties still do not have ties with other potential actors who could be important players within a water resource management scenario, such as, for example, the agricultural sector. As the network density is low, with only 23.9% of potential ties being present, the relationship between the stakeholders is considered to be disaggregated and as such there is no cohesive form of action in the water sector with a silo mentality prevailing. Similarly, only 31.7% of actors in the network have a reciprocated connection reflecting a low level of cohesion within the network. Network standard variation is high

further reinforcing the high variability that exists with those who are active and those who are not as well as those who are well connected and those who are isolated. Disaggregation can lead to information gaps between actors which, in turn, can lead to a lack of participation, broken lines of communication and a lack of full integration amongst actors. This undermines robust governance as it weakens the level of communication and participation as well as the integrative nature with which stakeholders are brought within the network. Such failures can indeed lead to a failure in the mutual understanding that needs to be created amongst stakeholders such that current problems are understood by all and courses of redress are better understood and designed taking into account of the inherent knowledge stakeholders who are involved in the day to day routines, can bring to sustainable policy design. The degree routine suggests the presence of fringe actors, such as farmer organisations and professional bodies, and therefore it is imperative to integrate these outliers to achieve a water policy that is comprehensive and inclusive. The fact that the identified farmer organisations are not connected to anyone speaks volumes particularly as the agricultural sector accounts for the use of 19.1 Mm<sup>3</sup> of water (NSO, 2010) of the 34 Mm<sup>3</sup> of groundwater abstracted annually (FAO, 2006) and the sustainable yield of the aquifer which the MRA has set at around 23 Mm<sup>3</sup> per annum. Network transitivity is low (22.91%), reflecting the ease of access that is possible amongst stakeholders. This may be attributable to the small size of the Maltese islands and hence it is easier to form 'friend of a friend' affiliations. In fact distance between actors is small and averages 2 paths which imply that information can flow easily between actors. This is supported by a low Network Centralisation (16.28%) indicating the absence of dependence on intermediaries and re-confirming the ease of facilitating affiliations. This suggests that Malta's socio-economic dynamics lend themselves easily to more integration amongst stakeholders thus fostering increased two way communication and participation, and hence a more robust water government framework. The regulator for water resources (MRA) emerges as the main actor in the water network. Other strong actors are the Environment and Planning regulators (MEPA-ENV and MEPA-DEV) as well as policy arm related to agricultural matters (RDP). This is significant as it demonstrates a recognisable regulatory function amongst stakeholders which augurs well for implementing rule of law. This is encouraging as whilst water infrastructure requires development permission, buildings also exercise an impact of water resources and as such at planning stage developers could be obliged to factor in their designs water conservation practices. The fact that Malta's WFD entrusts two competent authorities (MRA and MEPA) with its implementation may also be indicative of why such a close relationship evidences itself. The Ministry responsible for water (MECW) and the UoM should not go unnoticed in terms of their potential within the water sector. The Ministry has taken the correct step in segregating policy formulation from within the regulator and as such will be strengthening its capacity where water resources are concerned. It could very well be the case that we will see a growth in this stakeholder's status at the expense of the MRA which will now focus only on regulatory affairs. On its part the UoM needs to be involved further by the central authorities with a view to providing a learned yet unbiased and detached view for future policy making. The Malta Chamber of Commerce and Industry (Chamber) and the MHRA are the two strongest non-governmental actors. The former, in fact, has the closest relationship with the MRA. There are a number of reasons which could have yielded this perspective not least due to the fact that:

- both organisations represent specific private sector interests
- the Chamber and the MHRA have set up the MBB to look after the European aspect of their membership
- the MRA, Chamber and MHRA are partners in a Life+ project aimed to instil water conservation in industrial and tourism related buildings.

It is an example as to how collaboration can develop strong partnerships which are beneficial to the sustainability of the water sector. The level of connectedness is led by the stronger government-based actors (MECW, MRA, WSC, MEPA (Dev and Env), TM, Environmental Health, RDP, MA (Rural), PA (Rural), Malta Enterprise and Malta Tourism Authority. The University, MHRA and Chamber also contribute to connectedness from a non-governmental standpoint. The WSC (WSC) comes out as a strong power broker together with RDP through the betweenness routine. It is therefore not surprising that a number of cliques can be noted, depending on the minimum number of actors needed to form a clique. MRA, Chamber, MEPA (Env and Dev), RDP, MHRA and MECW remain the most influential actors in clique formation. All in all, this stakeholder analysis has demonstrated that the water sector is still disaggregated giving rise to a certain 'dominance' from a few actors. It has shown that the possibility of important actors being on the fringe truly exists whilst it has also shown that other relevant actors may not be as involved as they should be. All this mitigates against full participation by stakeholders in the development of water policy and which, in turn, undermines the robustness of local water governance frameworks. Notwithstanding, there is hope as it is also evident that the size of the island is small and contributes effectively to the 'friend of a friend' concept that serves to increase stakeholder interactions. In these circumstances, it should be the policy team which should take the lead with a view to working closely with all other actors and to ensure they are given equal access to participation and communication even, if cases may arise, where one or more stakeholders are not capable of working together due to their differing agendas or their lack of chemistry. It is only in this way that water governance may be mainstreamed into the workings of the competent authorities whilst knowledge of problems and best practices mainstreamed amongst all stakeholders. Social Network Analysis has become an increasingly popular tool for analysing network dynamics and has been used repeatedly in the health (Schoen et al., 2014; Kawonga et al., 2015), business (IEEE, 2010) and policy (Weishaar et al., 2015) areas in order to characterise interactions amongst specific actors. Each network analysis will have its own set of actors and specificities. The analysis of the water network could provide the opportunity for a similar analysis to be undertaken in the environmental and natural resource management sectors. It does not mean that the results will be identical but this study suggests that there may be disaggregated networks of stakeholders interested in such sectors and which consequently do not permit a more cohesive discussion to be undertaken with a view to understanding each actor's goals and constraints with a view to developing a more robust governance framework. So far, such studies have been absent in the light of consultation practices which were based on a responsive type of dialogue rather than one which evolves as a result of collective debate. The results that ensued are thought to have characterised the situation on the ground, confirming visual perceptions on the level of activity of stakeholders through grounded mathematical routines. This makes its

replication in other sectors recommended as a means for policy makers to better understand the formal and informal relationships between their stakeholders.

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