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Digital Perception Functionality for Institutional Design: The Forest Policy Issue of "Loch Lomond & the Trossachs National Park" of Scotland as a Case Study

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Abstract: Motivation for this research was the need to perceive the relations among actors involved in the rural-forest policy networks. The problem of an objective analysis of formal and informal power and information flow structure measurement and visualization in policy-making is tried to be solved. The policy network of "Loch Lomond & the Trossachs National Park" is used as a case study as it includes a great variety of actors. An answer to the much-discussed problem of digital perception of politico-administrative power are in part the results about: (1) how complexity of policy making can be measured and what this practically means, (2) who controls the communication, (3) where the most important information resources are located, and (4) who is most trustworthy in this network. It is concluded that: "Important" information is not a source of trust, but rather inversely, through trust one can impose information as being important. Between actors of relatively high trust status, the most trusted one does not need to control information in order to strengthen its position. A less trusted actor may supplement the lack of power status with information control. The leading role that forestry sector may play even in cross-sectoral issues is pointed out in this case study.
Keywords: Forest-environmental Policy, Cross-sectorality, Forestry & Rural Development, Network Analysis Software.

1 Introduction

1.1 Aim

Aim of this research is to present an example of policy arena perception through the social network analysis software Visone [1] [2] and to propose the enrichment of software which is engineered for social network analysis, with the algorithm of *complexity*. The design of such a software product is decisive for the perceptional output of a policy arena [4].

It is going to be shown that different algorithms reveal different structures (such as hierarchies of trust or information) which can empirically and qualitatively interpreted. The discussion will be extended on the role of the informal hierarchy of trust and information exchange and the complexity of a network. A particular environmental network is characterized by a single hierarchy of trust in which each actor is embodied. It will be shown that the position of each actor in this hierarchy is significant for the "importance" of the information that the actor distributes to the other actors of the network. Understanding informal structures is important because these structures, and not always the formal ones, determine policy outputs (e.g. roles, winners and losers, decisions, etc).

The following questions will be addressed: how *complexity* of policy making can be measured and what this practically means, who *controls* the communication, where the most *important* information resources are located, and who is most *trustworthy* in this network.

1.2 Literature review

"Smart" algorithms which should be abstract and simultaneously functional and meaningful for a wide range of heterogeneous policy fields, from GIS up to marketing and e-learning, is still a challenging issue in software engineering [3] [5] [13] [14] [16]. The examples suggested until now are mainly related to concrete fields such as environmental, spatial, industrial, commercial or military issues [6] [23]. Steps to more abstract fields of interactions concerning influence potential, administration and innovation have also been made [3] [9] [10] [11]. However, they depict a path leading to a more "immaterial" perception of social networks and thereby to sharper perception toward the institutional infrastructure of the reality. Many approaches have been presented in data mining and databases utilization [10] [11] [19] but only focused on classical statistics, without strong attention to the conception and perception of social structures. Such a perception of structures may also be a database with adaptive learning objects suitable for tentative policy planning and e-learning of lobbyists and policy-makers.

A basic hypothesis of decision making theory is that information does not produce power, but inversely, power seems to condition the role of information. Trust is a form of power: an actor who has gained the trust of the others can, in general, (mis)lead them with his/ her plausible arguments. The other dimension of power is trust: the trustor follows the trustee [12] [19] [20] [21] [22] [5] [6] [7] [8] [13] [15]. Trust is defined as the extent to which an actor is willing to let another actor make a decision for the former without exerting any control. In this way, a trustee may persuade the others that his/ her information is the most "important" and/or control the distribution of information (communication control).

1.3 Paper's Innovation

At theoretical level, this paper presents an approach of perceiving the institutional relations of the policy arena through software engineered for quantifying and visualizing policy networks. The system approach is not a method to analyze the reality but rather a pattern of perceiving it.

The practical added value lies in analyzing hierarchies structured in the framework of a real policy-making case. The results can be interesting for environmental policy-makers, lobbyists and policy analysts. The *complexity* algorithm is regarded as a software tool for policy analysis, which optimizes the functionality of digital perception and is suggested to be integrated in software products. This indicator is useful for examining which function of an actor is expected to be most or least important for a successful involvement in the network (the leading organs, the public relation officer, or the experts).

2 Case study: "Loch Lomond & the Trossachs National Park"

The "Loch Lomond & the Trossachs National Park" was selected as a case study as it is a policy issue directly related to forestry: typical conflicts between environmental groups and forest groups, agencies or enterprises (e.g. whether native or commercial species should be planted in this area) which appear in several European and American regions appear also in this case.

A public forest actor appears to be the strongest trustee and has achieved to be considered as the most "important" information source in this cross-sectoral policy issue. It has been argued [22] that forestry actors should avoid joining cross-sectoral policy networks or letting other sectors be involved in forestry issues because in this way the forestry actors become weaker. However, this case study offers a critical feedback to this hypothesis, as a public forest actor in Scotland can lead actors of several sectors (recreation, wood production, water and wildlife management etc) by gaining their trust and controlling scientific information, enhancing self-regulation of forest policy and forest policy analysis [13] [21] [14] [15].

3 The Proposed Methodology

Complete quantitative network analysis [17] [18] is applied. The empirical data have been collected through standardized telephone interviews with directors, chairpersons and campaign officers. The standardized questionnaire was based on previous intensive expert interviews.

The interviewees were asked to name the other actors which they had contact to in the process of the policy network. Afterwards, they were asked to cross-assess all actors which they had named regarding different variables, as for example: to what degree they trusted the other actors, who they considered had been their supplier of general and scientific information, amongst other variables etc. The separation of scientific knowledge from socially-constructed norms that are usually mixed in environmental policy [14] [16] was based on cross-assessment between the participants. Qualitative (in-depth) interviews with field experts have been conducted for the interpretation of the quantitative results.

For reasons of discretion the actors will not be named but only depicted as described in Figure1:

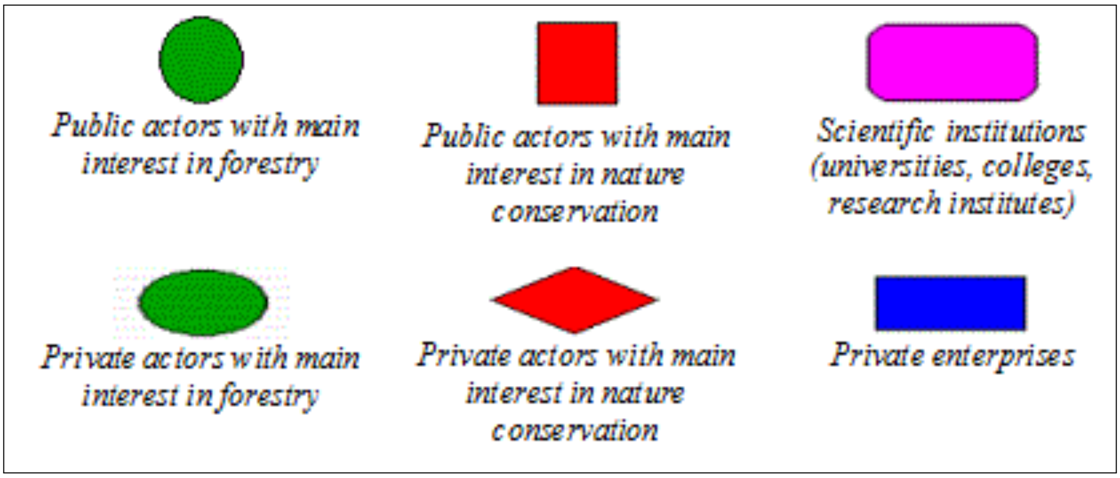

Figure 1: Legend of Actors in "Loch Lomond & the Trossachs National Park" Networks

3.1 Analysis of the socio-grams of "Loch Lomond & the Trossachs National Park"

The policy network approach is a form of system theory appropriately operationalized for policy analysis. According to the system theory, the interaction between the actors determines the properties of its actor (trust, importance etc) and the policy output (i.e. certain winners and losers). The system is in this case the policy network. The elements of this system are the participating actors (forest and land owner associations, enterprises, agencies, NGOs, universities etc) and the interactions between them are relations of exchange: offering and reception of information or trust. The policy output is derived from these interactions: The policy (issue) network approach assumes that the structure derived from these interactions explains policy outcomes (results of negotiations or other decision-making procedures, losers and winners). A network is specified through: a. the *issue* of interest, b. the *time* in which the interactions take place, c. the *content* of the relations (in our case, trust and information exchange etc).

Three hierarchies (also to be considered as 'sub-networks') concerning "Loch Lomond & the Trossachs National Park" in 2002 are analyzed using Visone [1] [15]: exchange of trust, of general information and of scientific information. General information means monitoring information (political-administrative events and evaluations). Scientific information means 'objective' description of functions and facts using expertise.

A basic mathematical entity for the following formulas is the *link* from actor i to actor j. If there is a link (e.g. information exchange) from actor i (e.g. forest service) to actor j (e.g. a certain environmental group), then this link is defined as: Z_{ij}. If there is no exchange in direction i→j then: Z_{ij}=0. The link of trust exchange is valued: Z_{ij}=1,2,3... . In the case of trust, the value of the link, when existing, is valued from 1 (no trust) to 3 (full trust). In other cases, as for example the information networks, the link was valued either with 0 (no existing link) or 1 (there has been a link).The total number of actors participating is defined as N.

3.2 From Density to Complexity

Density (D) is a characteristic of the entire network. It is defined as the proportion of all relations occurring in the matrix to the number of all possible links (N^2 -N) [18]:

$$D = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} Z_{ij}}{N^2 - N} \qquad (1)$$

where i≠j, Z_{ij} is the link from actor i to actor j and N is the total number of actors in the network.

If the network is visualized as a polygon, its density is the proportion of the existing diagonals to all possible (double-directed) diagonals. D is significant for the intensity of activity and for the extent to which all possible "chances" (contact places) of a network have been exhausted. However, this should not be considered to mena everything for the intensity of activity or the chances, because e.g. a network with N=4 and D=100% is still much simpler than a network of with N=50 and D=30%.

Thus, complexity (Comp) is proposed as a more accurate indicator of the practical difficulties that a lobbyist or policy maker has to be confronted with, if he/she enters the network. Comp increases with N and D and can here be defined as the average proportion of the (existent) links to each actor, which is the simplified product of N*D (the denominator is simplified from N-1 to N):

$$Comp = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} Z_{ij}}{N} \qquad (2)$$

The most complex of sub-networks of this case study is that of trust and not of information. The simplest one seems to be this of scientific information. The complexity is an indicator which implies the *intensity of tasks* for an organization which participates. Thus, in the case of the "Loch Lomond & the Trossachs National Park" management, the most challenging task is the development of trustworthiness. Second comes the general communication and last the scientific cooperation (Fig. 2 and Tab. 1).

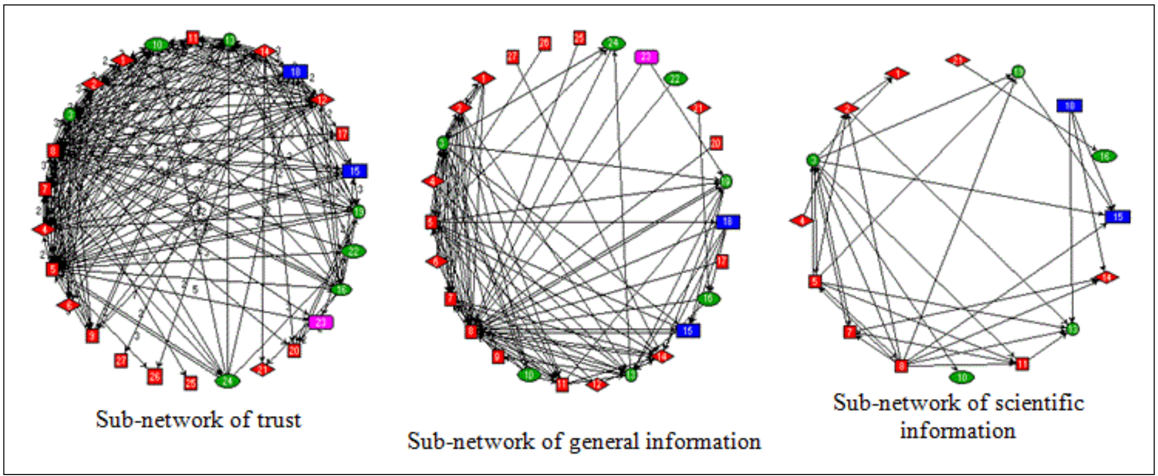

Figure 2: Visualization of the sub-networks of "Loch Lomond & the Trossachs National Park": Trust, general information, and scientific information

In Table 1, the links, the actors' number, the density and the complexity are presented for the three sub-networks. Practically, this means that a chairperson or a campaign officer who is responsible for strengthening the trustworthiness of his/ her organization is mostly stressed in the framework of this issue.

Table 1: Complexity of Trust, General information and scientific information in comparison

Content of exchange	Trust	General information	Scientific information
Links	184	98	34
Actor number (N)	27	27	16
Density (D)	27.25%	14.51%	14.16%
Complexity (Comp)	6.81	3.62	2.12

A secondary role is played by press officers that are responsible for general communication. Last come experts (e.g. biologists or environmental and forest scientists) who deal with scientific information, as the network of this kind of information is the simplest one.

3.3 Exchange Relations Functionality

Trust

Trust is a basis for prestige and concentration of jurisdictions, authorizations, and competence in decision-making. If e.g. the *Forestry Commission* trusts the *Royal Scottish Forestry Society*, which trusts the *National Trust of Scotland* and the last two trust the *Friends of the Loch Lomond*, then the last one proves the most trustworthy as it is able to gain the trust of all previous actors (also from the *Forestry Commission* indirectly). Thus, trust is a relational value created through successive transfer of reputation. For the reputation of the actor A, it is not merely important how many actors trust A, but also how much reputation these actors gain from other actors, etc [4].

The following formula for calculating the status of an actor in a network has been proposed [17]:

$$T = (I - aC)^{-1} - I \tag{3}$$

where T is a matrix including the status values of all elements, and C is the matrix presenting the real network (of trust exchange).

General information importance

The indicator Closeness Centrality (Cc) is based on the distance d (i.e. the shortest number of links) between two actors. If i.e. the *Royal Scottish Forestry Society* gives information to the *Friends of the Loch Lomond* and the latter to the *National Trust of Scotland* (and there is no direct information link from the *Royal Scottish Forestry Society* to the last one), then the distance from the *Royal Scottish Forestry Society* to the *National Trust of Scotland* is d=2 (links). The sum of all distances from an actor i to any other actor is the closeness of the actor i and then the closeness centrality of i is defined as its inverse closeness:

$$Cc_{(i)} = \left\lfloor \sum\nolimits_j d(j,i) \right\rfloor^{-1} \tag{4}$$

The fewer links are needed to connect i to any other actor, the higher its Cc is. If an actor has information that is regarded as *important* by the other actors, then one can expect this actor to have a high closeness centrality [2]. Thus, Cc is used as an indicator of the information importance.

The information control

The index Betweenness Centrality (Cb) quantifies the information control exerted by an actor i and is defined as the sum of the ratios of shortest paths between other actors that the actor i sits on:

$$Cb_{(i)} = \sum \frac{|P_i(i,j)|}{|P(i.j)|} \tag{5}$$

where P(i,j) and P_i(i,j) are the sets of all shortest paths between i and j, and those shortest paths passing through i, respectively.

Thus, an actor with a high percentage of Cb plays the role of the go-between for many other actors in term of shortest paths and, in this way, it can control the distribution of information within the network [20] [21].

It should be clarified that Cb shows who is the most crucial "postman" of information in a network, while Cc shows who is the most important "sender" who can thereby impose an opinion and function as decision-maker.

4 Results and discussion

4.1 Meta-data: Trust

Formula 3 defines the position of each actor in comparison to the others. A public forest actor (actor 3) and two public environmental actors (actors 5 and 8) take the top positions in the scale of the trust status (T) (Fig. 3). Despite the dominant hypothesis that forest policy is outside-controlled (namely by other sectors that may be commercially more important like tourism, water policy etc) [21], in this case a powerful forest actor seems to play a leading role. In Figure 3, the trust status is measured on the vertical dimension in %. The horizontal dimension has no meaning. The top three values are:

$$T_3 = 8.80\%, T_5 = 8.35\%, T_8 = 7.80\%$$

The nature conservation agencies have more intensive presence (actors 5 and 8) while the most powerful actor is from the forestry sector (actor 3). These three actors belong to the *public* and not to the *private* sector.

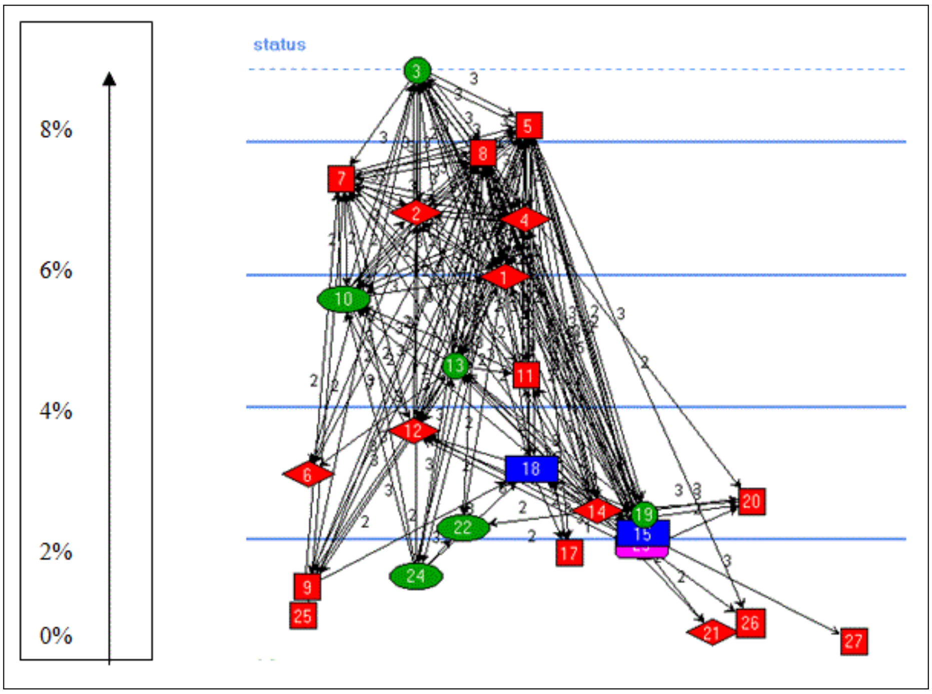

Figure 3: Hierarchy of trust status

4.2 Meta-data: Communication

- General information importance.

The public conservation actor 5, the public exploitation actor 3 and the public conservation actor 8 possess to all appearances the most crucial general information resources in the network (Fig.4):

$$Cc_{(5)} = 5.50\%, Cc_{(3)} = 5.24\%, Cc_{(8)} = 5.00\%$$

The closer the actor is to the centre, the higher the closeness centrality of the actor; which means a higher position in the general information hierarchy.

The lines surrounding the centre represent different and lower values of closeness centrality, while moving further away from the centre of the circle. The order of the actors around a circle (polar coordinates) has no sociological meaning; the circular order has been carried out automatically by Visone software so as to minimize over-crossings.

A public agency for nature conservation is regarded as most important in the network (actor 5). A public agency for forest management (actor 3) lies quite close to actor 5. Third comes actor 8, which is again a public agency of nature conservation. All other public actors (such as 7, 11, 13 etc) as well as all private actors (environmental NGOs such as 26, 25 etc and land owners or forest associations such as 10, 16, 22, 24) lie quite far from the centre. Thus, this network is dominated by a few actors of the public sector, while the private sector does not play leading role. It is also noticeable that the reputation of the involved scientific institution (actor 23) is very low.

The actor which achieves to impose its information as most "important" is not the most powerful one. In this case, the most "important" actor is a conservation agency (actor 5). It seems that the powerful forest actor (actor 3) shares the general information importance with the conservation actors 5 and 8. The conservation actor 5 has achieved a higher influence in general information. This may occur because nature conservation is of interest for a larger part of the public and policy sectors than a forest actor, and this actor has generally a good reputation.

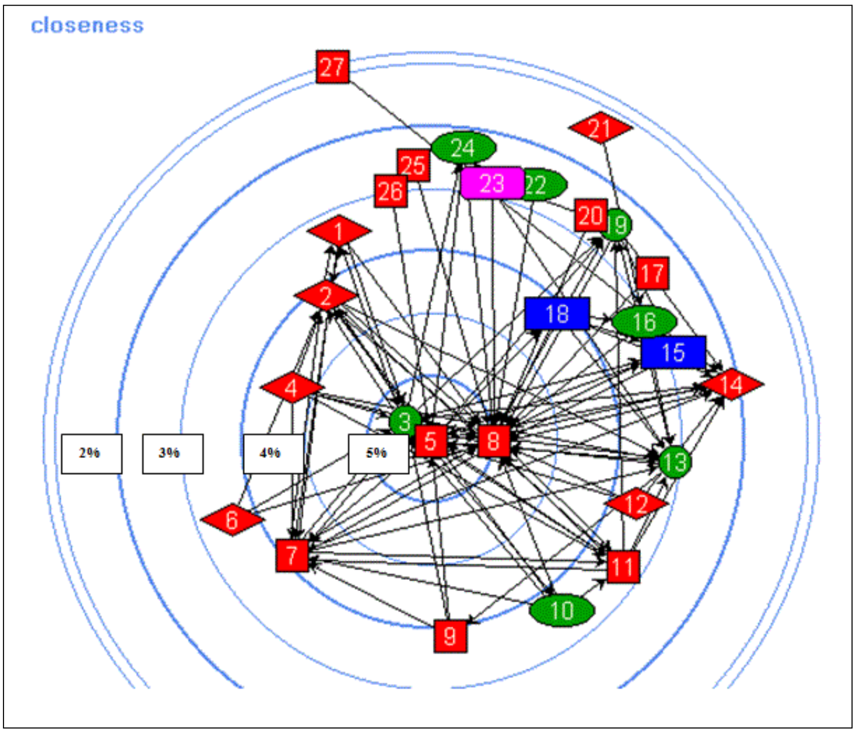

Figure 4: Closeness centrality in general information

- General information control.

Figure 5 shows that actor 8 exerts the strongest control on general information distribution. In figure 5, the Cb is measured in % and decreases from the centre to the periphery, while the circular order was carried out again by Visone software so as to minimize over-crossings and has no sociological meaning. Actor 5 is second, and third comes actor 3:

$$Cb_{(8)} = 42.24\%, Cb_{(5)} = 17.04\%, Cb_{(3)} = 14.15\%$$

A practical meaning of Cb is that if actor 8 was to leave the network, most information channels would be destroyed and most actors would experience a noticeable lack of information. Although actor 5 is considered to be the most "important" one (s. above Cc), the largest part (42.24%) of information channels is sustained by actor 8. In other words, the most important "sender" of politico-administrative information is supposed to be actor 5, but the most crucial "postman" of this information is apparently actor 8. Without actor 8, actor 5 would lose its influence because the distribution of its information would be hindered. Thus, someone who is aware of this network structure is able to differentiate the "sender" from the "postman" and can try to influence the first one in order to achieve a substantial change in the policy content or in the communication of the network.

However, although the same three powerful actors hold the top three positions in the general information control, there are noticeable differences between them; It is observed that the most powerful exploitation actor 3, is the weakest of the three in general information control. Simultaneously, the conservation actor 8, which occupies the last rank among the three actors in power and general information "importance", exerts the strongest control on the distribution of general information.

This difference between power, information importance and information control is the clearest evidence that information is not a resource for developing power. Although the most powerful actor is an exploitation actor (actor 3), it has left the communication functions ("importance" and control) to two conservation actors, 8 and 5. Although actor 5 has gained a stronger reputation ("importance" in general argumentation), actor 8 seems to have been involved in more communication channels and sub-networks.

The same three public actors control the general communication of the network while the rest actors lie at the periphery of the network once again. The scientific institution (actor 23) plays again a very weak role in the control of general communication.

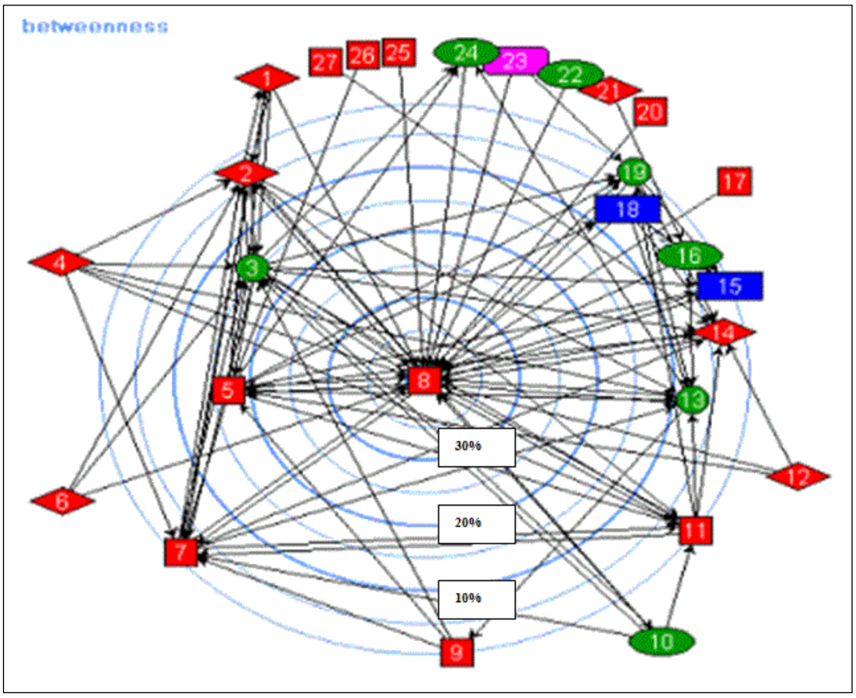

Figure 5: Betweenness centrality in general information

4.3 Meta-Information: "Objectivity"

- Scientific information importance.

Assuming that scientific information has been distinguished from political and social norms in our empirical research, the importance of the "objective" expertise can be measured in this network. As already shown (Fig.1), only 34 out of 98 information links (34.6%) consist of scientific information, while these 34 links are only 18.4% of the total interactions (184 links). In other words, science plays a rather weak role in the network. Thus, one can achieve only a weak influence on the policy outcome using "brilliant" expertise.

Indeed, the public actors 8, 5, 3 monopolize once again the index Cc (*importance*). Although actor 8 possesses the lowest trust among the top three actors (Fig. 2), it has the highest Cc in scientific information (Fig.6):

$$Cc_{(8)} = 21.56\%, Cc_{(3)} = 18.69\%, Cc_{(5)} = 17.52\%$$

A different ranking between the top three actors is observed. Actor 8 is considered to be the least "important" of these three in general information, but it is regarded as the most "important" one by the few science-interested actors. This phenomenon shows that science and general communication (politico- administrative information) are two quite autonomous worlds with different hierarchies and priorities (what or who is "important" in the one world is not necessarily equally "important" in the other). Scientific reputation does not necessarily depend on the formal identity of an actor: the scientific actor 23 does not appear at all in the scientific communication network.

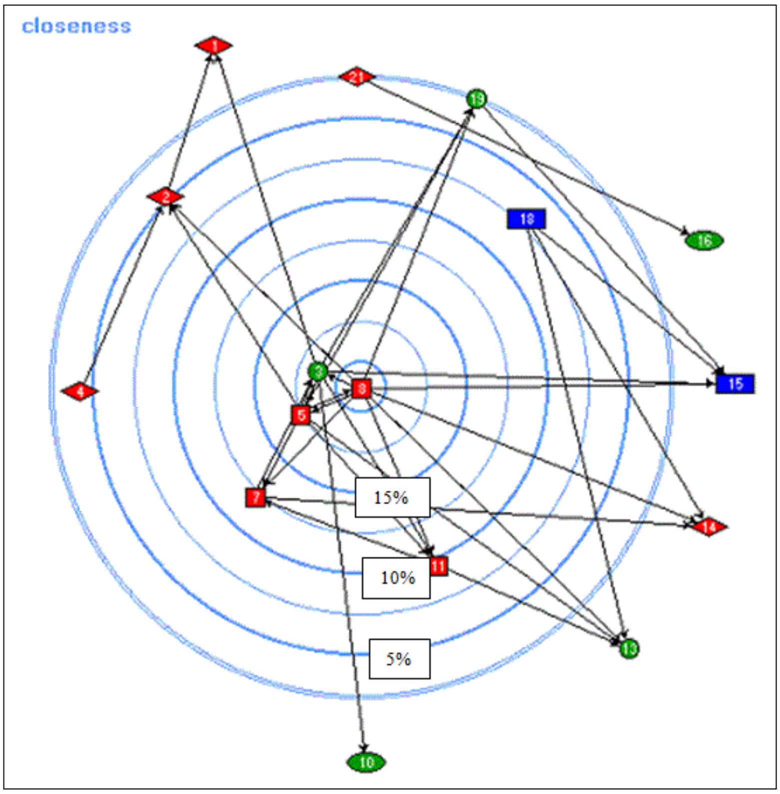

Figure 6: Closeness centrality in scientific information

- Control of scientific information.

In our study, the control of scientific information seems to be more relevant to the status of power. Actor 3 is the most trustworthy and simultaneously has the highest Cb, while actor 8 does not even appear among the top three (Fig. 7):

$$Cb_{(3)} = 45.74\%, Cb_{(7)} = 23.26\%, Cb_{(5)} = 16.28\%$$

The forest actor (actor 3) seems to be strongly involved in scientific sub-networks and to control the scientific communication with its forest expertise even in such a cross-sectoral issue like "Loch Lomond & the Trossachs National Park". This constitutes evidence that despite its multidisciplinarity [16], Forest Science can be self-regulated and can offer a sound basis for political negotiation and management even in cross-sectoral issues. Although actor 8 was considered to be most "important" in scientific information, if it leaves the network, it will influence the scientific communication between the actors only little; the other actors have alternative access to its "important" information; This practically means that an "important" (crucial) source is not necessarily irreplaceable.

Actors 3, 7 and 5 are *public* actors. Thus, the control of scientific communication is still dominated by the state while the private sector plays quite a peripheral role. The scientific institution (actor 23) does not appear at all.

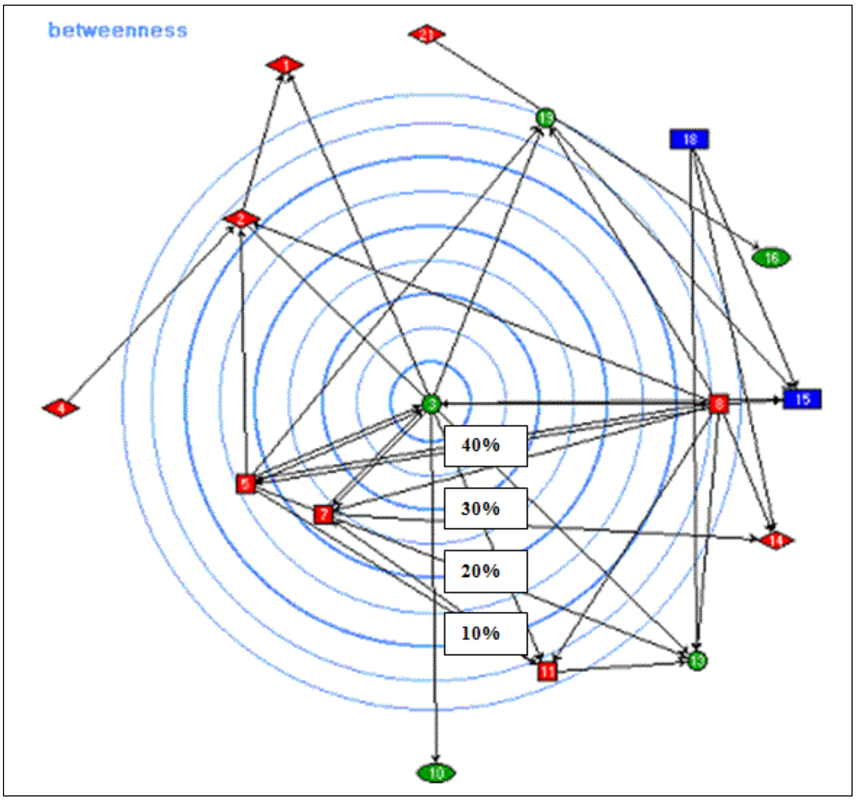

Figure 7: Betweenness centrality in scientific information

5 Conclusions

Using software for social network analysis, the politico-administrative reality can be perceived as a system of hierarchies (formal or informal ones). The exact perception output depends on the engineering design of the software, namely of the algorithms included in the program. Each algorithm applied to an appropriate type of relation (e.g. trust or information) produce a different output-aspect of the politico-administrative reality.

It was observed that the actors 3, 5 and 8 are the top three in trust status. The same ones occupy the first three places in almost all of the four centrality indicators of information exchange (closeness and betweenness in general and scientific information) however, not in the same position. There is a marked differentiation among them: the most trustworthy, actor 3, neither possesses the most important general information (Cc of general information) nor exercises the strongest control on its distribution (Cb of general information). The least powerful, actor 8, exerts a remarkable control on general and scientific information (Cb of general and scientific information). Actor 8 may fix up its deficit in trust status through information control.

The control of information is not necessarily based on the trust (practically meaning legitimacy or acceptance) but rather on the involvement that an actor has achieved in a network. Self-evidently, a network-experienced actor is expected to have more opportunities of becoming more strongly involved. The most powerful, actor 3, mainly exerts its control potential on the distribution of scientific information. However, it was also shown that scientific information plays a much weaker role in the network than the general information. Therefore, a powerful actor is supposed to implement its power using general information rather than expertise.

The following hypotheses are supported by these findings. Specifically:

1. "Important" information is not a source of trust (as a power component).

2. Between actors of relatively high trust status, the most trusted one does not need to control information in order to strengthen its position. A less trusted actor may supplement the lack of power status with information control (which makes this actor irreplaceable).

3. Possessing information resources which are regarded by others as "important" does not appear to be very strongly related to the trust position.

A practical advice for forest and environment-related actors that derives from this analysis would be to set strengthening of their image as a first priority and not to acquire "important" expertise because it does not seem to be so relevant to their trust status and leading potential. An actor with a strong reputation may even be more influential in science than purely scientific institutions. Scientific information does not necessarily play a decisive role in policy making. By gaining trust an actor becomes powerful in a network and thus can define which information is "important". Finally, an "important" actor (sender with high closeness centrality) is not necessarily irreplaceable; It has only persuaded many others that it possesses crucial (very useful) information for them. As presented, this information can also be accessed through an actor with high betweenness centrality which acts as a "postman". However, a drastic change in the information content distributed in the network can be achieved only if the sender is influenced.

An additional lesson which is of interest specifically for the forestry sector is that the cross-sectorality is not always unfavorable for the forest actors, though it makes the power relations uncertain. As shown, a powerful public forest actor in Scotland plays a leading role in a quite cross-sectoral issue like that of the "Loch Lomond & the Trossachs National Park". Moreover, it manages to control the cross-sectoral scientific communication.

The quantitative network analysis is an operational form of system theory in policy analysis that can produce meaningful data, if the contents of the exchange relations (giving and receiving of trust, information etc) are clearly operationalized. Socio-informatics can open up new ways of describing politico-administrative structures and predicting power in multi-sectoral policies like rural development or forest-environmental policy. Particularly, it can help in the description of informal hierarchies like these of trust, information "importance" and communication control which determine the policy output. It is possible that an actor may lose in a policy issue, because it is unaware of its own power (trust) status (trust) or because it confuses the information "importance" (closeness centrality) with the information control potential (betweenness centrality).

The "Loch Lomond & the Trossachs National Park" is only an example of applying quantitative network analysis to environmental issues. By using larger sample of networks in future research, analyzing further exchange relations (like financial means, pressure etc) and employing complementary qualitative methods, like document analysis and observation, a more accurate and effective policy consulting can be achieved.

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