Exploring farmers' interaction with landscape, society and environmental regulation using Fuzzy Cognitive Mapping

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Abstract
The way farmers translate the framework of agricultural policies, farm economics, environmental regulation, societal needs and wishes as well as personal views, values and preferences into landscape management decisions is as of yet under-researched. Policy-making could become easier and better targeted if the mechanisms driving the landscape development were better understood.
This presentation is about the use of 'Fuzzy Cognitive Mapping' (FCM) to elicit information on the interconnectedness of drivers of agricultural landscape use and change. FCM is based on an Idea from Bart Kosko to extend cognitive and mind mapping approaches in management studies and has recently been adapted to applications in landscape level socio-ecology and -economics. It is a 'weighted graph', put together during an interview or workshop that allows for comparison between different case studies and can be used to address 'what-if' questions and simulate the changes of a complex system in response to e.g. policy interventions.
In this study, it is used to compare two Danish and Scottish research landscapes with the aim of formulating policy recommendations in the field of agro-ecosystem services. The emerging strength of the approach lies in the ease of combining academic, regulatory and practical local knowledge into an expert network in an unbiased way. It is also very conducive for actively engaging stakeholders in the research process.

1. Introduction
For successful policy making and sustainable development to occur, many stakeholder groups need to be involved in the process. Within this process, a scientific approach that can quantify the subjective perceptions of the different stakeholder groups can be useful. Such a method can be helpful both to obtain the support of the participants and to compare the similarities and differences among groups of stakeholders and determine the main obstacles to successful policy implementation. It may also make it easier for the involved stakeholders to accept the results. Fuzzy Cognitive Mapping (FCM) offers such an analysis (Eden 1992, Özesmi 1999a, b). In this research, fuzzy cognitive mapping was applied to the question of how environmental regulations affect farmers, farming and the development and utilisation of the farmed landscape in general.

2. Methodology and empirical data collection
A Fuzzy Cognitive Mapping (FCM) approach was used in this study. Fuzzy cognitive maps are models of how a given system operates based on defined variables or concepts and how these concepts influence or cause each other. These concepts can be measurable physical quantities such as fertilizer application rates or complex aggregate and abstract ideas such as landscape aesthetics or personal happiness. The person creating the fuzzy cognitive map decides what the important concepts are that affect the system and then draws causal relationships among the concepts indicating the relative strength of the relationships with an entirely subjective number between -1 (strong diminishing effect) and 1 (strong increasing effect) with incremental steps of 0.1. Once the maps are drawn, their structure can be analysed using graph theory and their outcomes determined through fuzzy cognitive mapping computations. Cognitive mapping has been used to look at decision-making and conceptions of complex social systems. Kosko (1986) coined the term fuzzy cognitive map when he modified cognitive maps by applying fuzzy causal functions with real numbers to the connections. Kosko (1987) was also the first to determine the outcome of an FCM, as well as to model the effect of different policy options.

For the Danish part of the study, 3 mapping workshops with a total of 15 farmers were held. The Scottish part consisted of one workshop as part of a meeting on diffuse pollution mitigation with 9 people from administration, policy making, consulting, conservation and agricultural sciences as well as one farmer and a farmers' union representative. Additionally, 9 one-on-one interviews on location were held; 7 of which were farmers, one agricultural consultant and one estate manager. The names of the participants and interviewees were noted, together with background to their occupation and in the farmers' case some details about their farm business (arable, mixed or livestock; acreage; participation in environmental schemes; crop-rotations; use and ownership of machinery; logistics; local landscape specifics and climate). The interview was on the topic of environmental regulations in general and their effects on farmers, their business and the farming landscape.
After the interview-part, the participants were shown the process of creating an FCM on an unrelated topic to explain the process. The Scottish participants were then asked the question 'How do environmental regulations affect farmers and farming practice and what is important for compliance/non-compliance with GBRs? The question was also printed as heading on an A3 sheet of paper used to collect concepts and to draw the actual maps. The additional information gathered during the interview was used to supply the interviewees with starting points in their own words when asked to think of concepts to put on their FCMs and to validate the resulting data afterwards.

3. Results and Discussion

By looking at the most central variables, we can understand which variables are most important in a FCM. By looking at the outdegree and indegree, we can see how much these central variables affect and are affected by other variables. In this way it is possible to understand the relationships of variables in the maps. By looking at the most central variables in the stakeholder groups' cognitive maps, it is possible to see the differences and similarities in what variables the groups perceive as important. The farmers' group has bureaucracy as clearly most important concept, followed by cost, time requirement, biodiversity and business viability. The non-farmer group has compliance as concept of utmost importance, followed by cost, knowledge and education, enforcement and awareness. The farmers' map has a high percentage of transmitter variables (no indegree), indicating their feeling of being under control from outside forces outside of their own influence. As expected, the non-farmers group containing policymakers and consultants has a low number of transmitter variables.

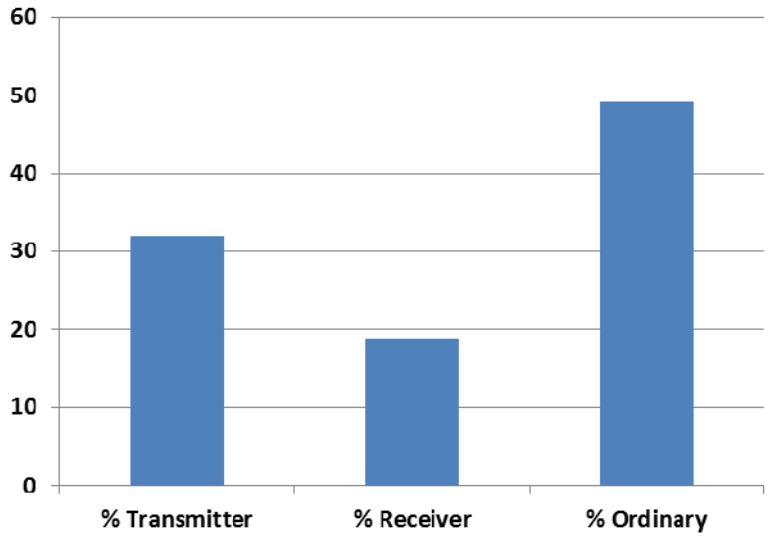

Figure 1. Percentage of different variable types in the farmers' group

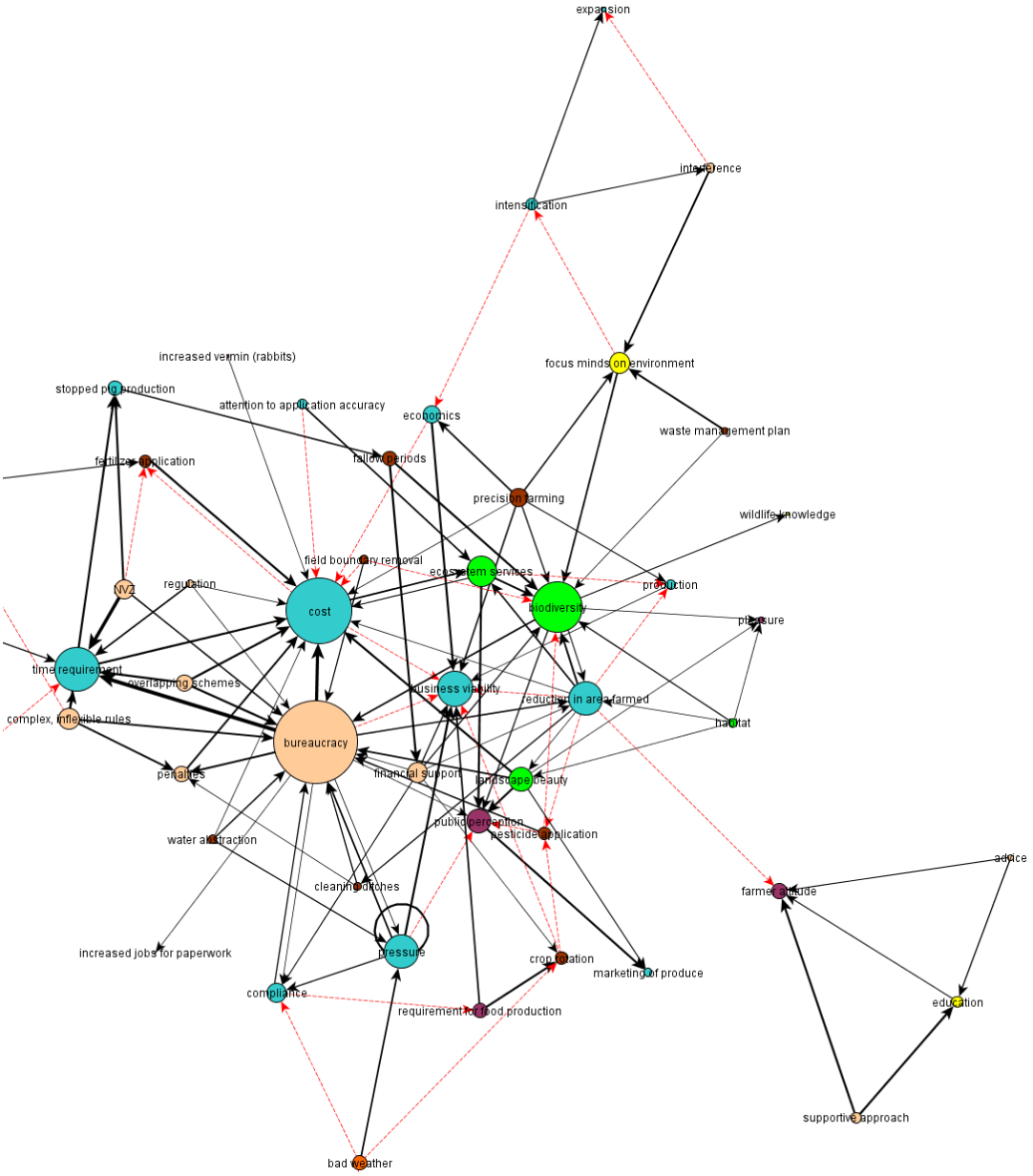

Figure 2. Central parts of the combined FCM network of the farmers' group.

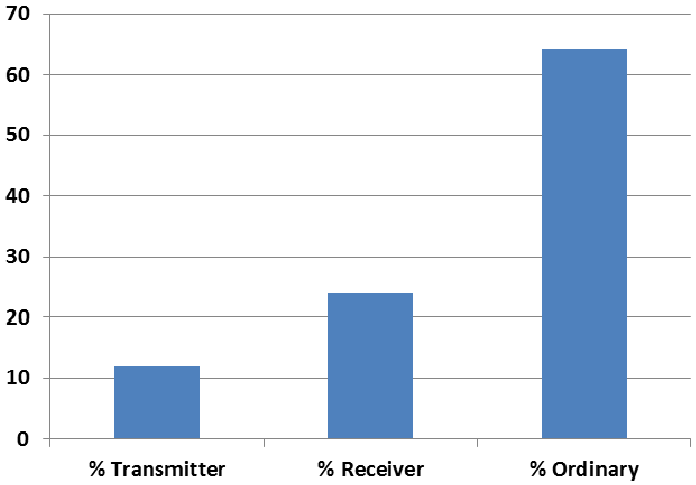

Figure 4: Percentage of different variable types in the farmers' group

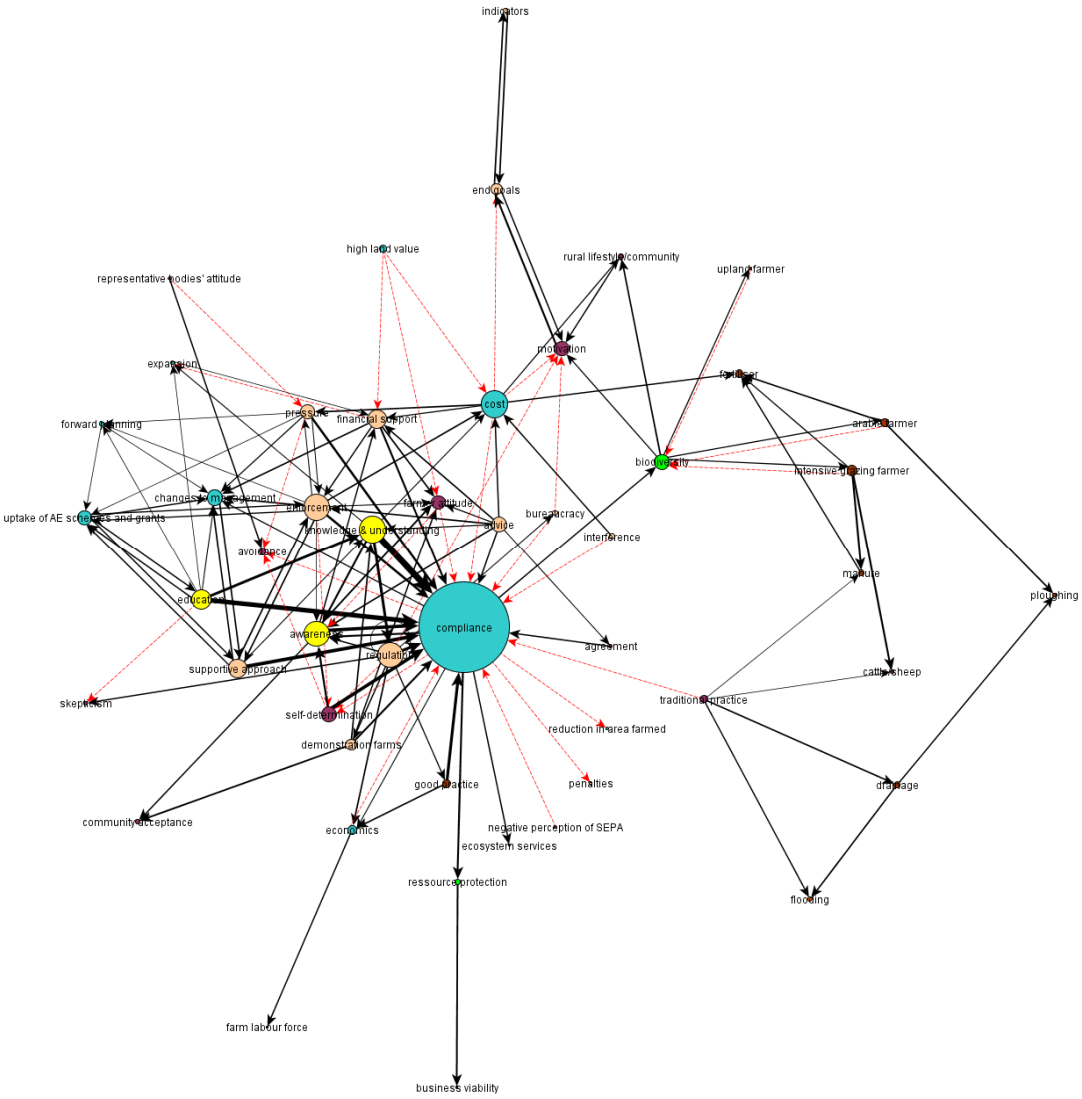

Figure 3: Combined FCM network of the non-farmers group

5. Conclusions

A number of possible policy recommendations can already be derived from this study as it painted a very clear picture despite the relatively low number of participants, showing the applicability of FCM in informing policy making. The main strength of FCM is facilitating communication between researchers and stakeholders as well as internally between different stakeholder groups. The visualisation options leave a strong impression and the intuitive process delivers results that are less likely to be 'what the interviewer probably wants to hear'. Additionally, the method removes the professional bias by putting the local, administrative and scientific knowledge on an equal footing in an expert network.