Initial diagnosis of local context for agricultural development projects: cognitive maps to conceptualize socio-ecological systems and elicit stakeholders' viewpoints

Tardivo Caroline[1, 2], Delmotte Sylvestre[1], Le Page Christophe[2], Barbier Jean-Marc[1] and Cittadini Roberto[1, 3]

1 INRA, Département SAD, UMR Innovation, 34070 Montpellier, France

2 CIRAD, UPR GREEN, Montpellier F-34398, France

3 INTA, Labintex, Argentine

Abstract: This communication presents a diagnosis of the local context as a preliminary step to support collaborative learning for agricultural development at the regional scale. Our method is based on a two-step investigation: a description of the socio-ecological system (defined in this paper as the combination of the agricultural system, the ecological system, and the local socio-economic system) and a stakeholder analysis aiming to support the design and the evaluation of the forthcoming participatory process. Cognitive maps (CM) are used to formalize both analyses.

Twenty semi-structured interviews were conducted in a south-of-France agricultural region, the *plateau de Valensole,* with various stakeholders concerned with the development of agriculture and who have different missions and knowledge (heads of cooperatives, advisors, representatives of public organizations, representative of farmers' unions…). The interviews focused on the description of the region, on stakeholders involved in agricultural management, and on the current state, issues and possible evolutions of the agricultural system. Based on interviews' transcripts, a CM was built for each of the twenty interviewed stakeholders. Each map contains the concepts quoted by the interviewee (structural components, stakeholders and characteristics) and their links characterized by cause-effect relationships. During the forthcoming steps, the CMs will be completed and validated by a second round of interviews with stakeholders. They will then be compared in order to support a stakeholder analysis based on stakeholders' viewpoints. They will also be aggregated in order to conceptualize the socio-ecological system, to be potentially used later for a computerized model.

In this paper, we present two resulting maps to show their contribution to the socio-ecological system conceptualization and stakeholder analysis. Those cognitive maps allow for synthetizing types of knowledge (e.g. empirical, technical and scientific) and many viewpoints at different scales (e.g. field, farm and region).

Keywords: socio-ecological system, cognitive maps, stakeholder analysis, agricultural systems, agricultural development

Introduction

The participation of stakeholders in research and development projects targeting the sustainable development of agricultural areas has proved to be essential (Faure et al., 2010). This participation ideally takes the form of collaborative learning, a process through which stakeholders' viewpoints can be articulated and knowledge shared (Reed et al., 2010). Such kinds of projects start with an initial diagnosis of the local context (Barnaud et al., 2006 ; Faure et al., 2010). In the literature, two types are highlighted:

- **Diagnosis of the socio-ecological system:** Applied to agricultural regions, we define a socio-ecological system as the combination of the agricultural system, the ecological system, and the local socio-economic system. This definition includes the identification of embedded supply chains. Such a diagnosis aims to analyze the current characteristics and dynamics of the socio-ecological system and is used as support for collective thinking about agricultural sustainability (Delmotte, 2011). It is argued that such a system diagnosis has to be realized among multiple spatial and temporal scales (Ostrom, 2009). The following points are necessary in order to address the multifunctionality of agriculture in this diagnosis: (i) the identification and description of the main agricultural activities (e.g. cropping and livestock systems) and non-agricultural activities (e.g. supply chains, agro-tourism activities, protection of biodiversity…); (ii) the elicitation of system dynamics by the exploration of cause-effect relationships within the system; (iv) the understanding of the main issues and opportunities for the studied area (Rossing et al., 2007).
- **Stakeholder analysis**: Supporting collaborative learning seeks to take into account and articulate the different *viewpoints* stakeholders have on the studied area and topic (Reed et al., 2010). For this research project, our definition of a 'viewpoint' is the way stakeholders perceive their environment, including their goals, interests, knowledge and expertise (Grimble & Wellard, 1997 ; Faure et al., 2010). Viewpoints are structured according to stakeholders' scales of interest, defined as the scale to which objectives are focused, and scales of influence, defined as the scale to which stakeholders' actions occurs. The stakeholder analysis includes also a *social network analysis,* that supports the identification of current coordination and negotiation structures (Prell et al., 2009). For projects targeting the sustainable development of agricultural regions, stakeholder analysis aims at (i) selecting stakeholders who should participate to the project, using criteria such as representativeness and equity (Prell et al., 2009), (ii) adapting the design of the participatory process to the social and institutional context (Mathevet et al., 2010), and (iii) serving as baseline for the evaluation of the process, in terms of impact on stakeholders' perceptions and interactions (Barnaud et al., 2006).

Completing these two diagnoses requires the synthesis of many types of knowledge (e.g. empirical, technical and scientific) and many viewpoints at different scales (e.g. field, farm and region). Additionally, these diagnoses draw upon various disciplines (e.g. agronomical and environmental sciences, sociology, geography, economy and management sciences). A method encompassing this diversity is therefore needed. Cognitive maps (CM) proved to be relevant for addressing complex systems and incorporating the diversity of knowledge formalized through different disciplines (Jones et al., 2011).

Eden (2004) defined CMs as visual representations of complex systems, abstracting relationships between concepts or stakeholders through lines and arrows. CMs have been used for different purpose:

- **Cognitive mapping for stakeholder analysis**: CMs have been used in order to elicit the way people self-represent a system and its dynamics, and are therefore assimilated to mental models (Becu, 2006). Individual cognitive mapping methods are used to elicit viewpoints that are held by the different stakeholders involved in the management of a socio-ecological system

(Jones et al., 2011 ; Mathevet et al., 2011). Comparison of these different viewpoints is therefore possible and contribute to the stakeholder analysis as defined above (Hjortsø et al., 2005). It can be realized thanks to statistical methods, allowing for the comparison of a great number of CMs (Markoczy & Goldberg, 1995 ; Mathevet et al., 2011 ; Schaffernicht & Groesser, 2011).

- **Cognitive mapping for socio-ecological system conceptualization**: Collective CMs have been used for qualitatively modeling agricultural, socio-ecological or management systems. In this case CMs often take the form of causal maps (defined as CMs for which relationships are causal), and consider concepts as variables of the system (Fairweather & Hunt, 2011). Fuzzy CMs, defined as CM for which relationship intensity is quantified, allows for semi-quantitative analysis (Özesmi & Özesmi, 2004). Especially used for socio-ecological systems, conceptualization aiming to take into account empirical knowledge, fuzzy CMs allows for dealing with different degrees of accuracy, though quantification of the probability of relationships (Kosko, 1986). System conceptualization through causal maps can also be used as a base for scenario development (van Vliet et al., 2010) or agricultural system design (Gouttenoire, 2010). Methodological developments aim to use CMs as conceptual models for simulation tool development and as a support for scenario building (Dray et al., 2006 ; van Kouwen et al., 2008 ; Le Page et al., 2010 ; Etienne et al., 2011).

CMs can be built using three different approaches:

- Collective cognitive mapping (Mendoza & Prabhu, 2006 ; Gouttenoire, 2010 ; van Vliet et al., 2010 ; Etienne et al., 2011),
- Individual cognitive mapping with each stakeholder, then maps aggregation (Dray et al., 2006 ; Fairweather & Hunt, 2011).
- Individual cognitive mapping by the researcher from semi-directive interview coding, and aggregation (Özesmi & Özesmi, 2004 ; Vanwindekens et al., 2013).

In this paper, we present a preliminary analysis that we are in the process of undertaking in the Plateau de Valensole, South of France. It is in the context of this 'research and development' project, that we are mobilizing the CMs discussed in this paper. We present (i) the way we built the CMs, (ii) examples of resulting CMs, and finally (iii) the type of analyses that we are working towards. As this is an ongoing project, the foreseen next steps and final outcomes are presented but still subject to modification according to the needs and realities of the participatory process.

Method for analysing the socio-ecological system of the plateau de Valensole, South of France

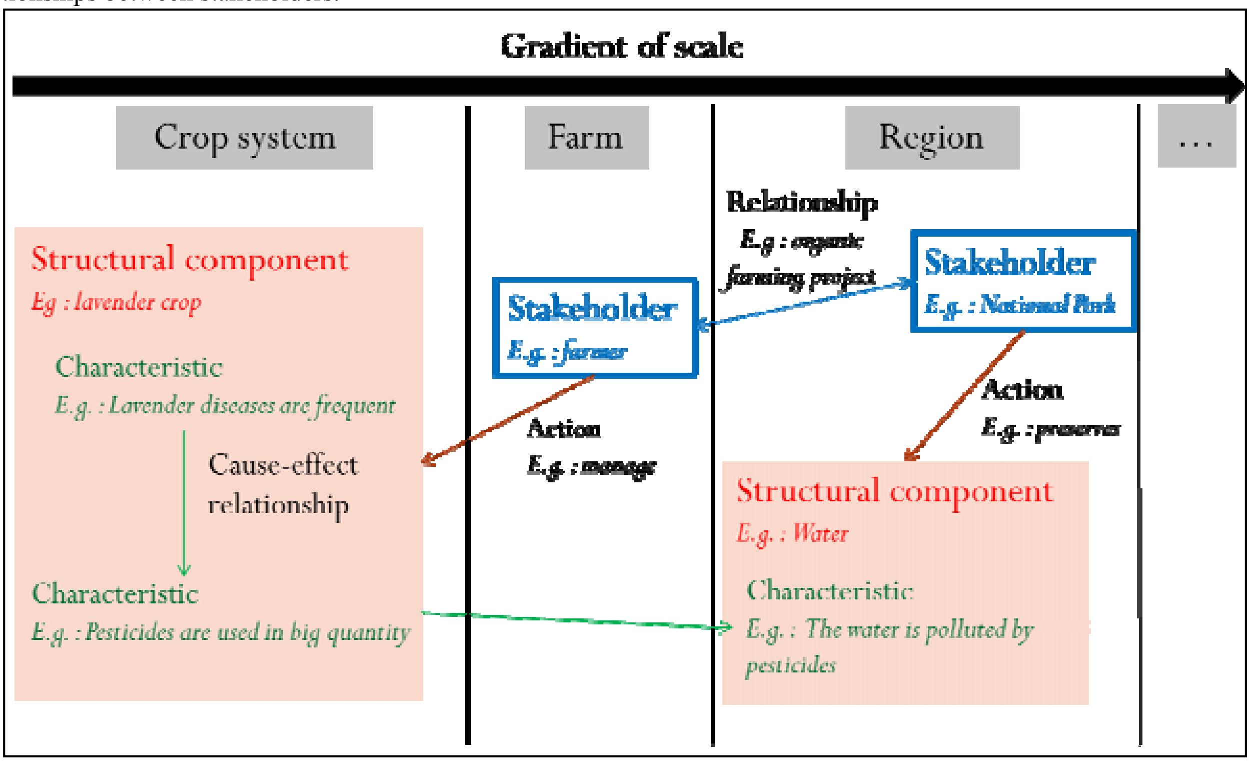
This initial diagnosis is the first step of a project which aims to integrate local stakeholders into the design of a negotiated action plan for the agricultural development of the Plateau de Valensole, a 80 000 Ha agricultural region, in the south of France. This region is characterized by production systems mostly based on lavender and durum wheat, leading to famous working landscapes – notably when the lavender is in bloom – that attract a lot of tourists.

Our research started with interviews of the main stakeholders in the region, from which we developed CMs. The next steps of the methods (§ iii to v) are still on-going but presented here to show the logic of the already completed activities.

- **Individual interviews:** Twenty semi-structured interviews were conducted with various stakeholders concerned by the development of agriculture in the *plateau de Valensole* (heads of cooperatives, advisors, representatives of public organizations, representatives of farmers' unions…). All interviews were recorded and transcribed. The interviews were structured according to four axes, inspired from patrimonial audits methodology (Jésus, 2001): a. *What are the missions and activities of the institution? b. What are the issues and opportunities of local agricultural systems and supply chains? c. What are the institutional and individual on-going projects? How do stakeholders coordinate their actions? d. What evolutions can we expect – with hopes or fears - for agriculture in the region?*

- **Individual cognitive mapping by the researcher**: At this step of the project, local stakeholders were not yet enlisted in the project and individual interviews constituted the first meeting with them. The researcher therefore built the maps directly from interview transcriptions, and in an individually way (in order to catch individual viewpoints). The map is structured according to spatial scales. Structural components (defined as a physical or abstract object of interest for the interviewee) mentioned by the interviewee are integrated according to their relevant scales. A structural component can be an agricultural component (e.g. a simple crop, a crop rotation), a natural resource (e.g. water), or a socio-economic entity (e.g. a farm). The stakeholders mentioned by the interviewee are also positioned according to their scale of influence. The structural components and stakeholders are described by their main characteristics, which are linked by causal relationships. Actions of stakeholders on structural components and relationships between stakeholders are also made explicit and described by a few words on an arrow (Fig 1.).

Figure 1 : structure of Cognitive Maps used in the method. In black, the spatial scales. In red, the structural components and in green their main characteristics. In blue the stakeholders. Grey arrows are cause/effects relationships. Red arrows represen Red arrows represent actions of stakeholders on structural components. Blue arrows are relationships between stakeholders.



- **Validation and completion of CMs:** During a second round of interviews, CMs will be presented and discussed individually with stakeholders. Interviews will be structured around: (i) the validation and completion of the system conceptualization; (ii) the identification of the main issues by the interviewee; (iii) the completion and validation of interviewee's activities and of their consequences on socio-ecological system (iv) the discussion about the relationships with other stakeholders.

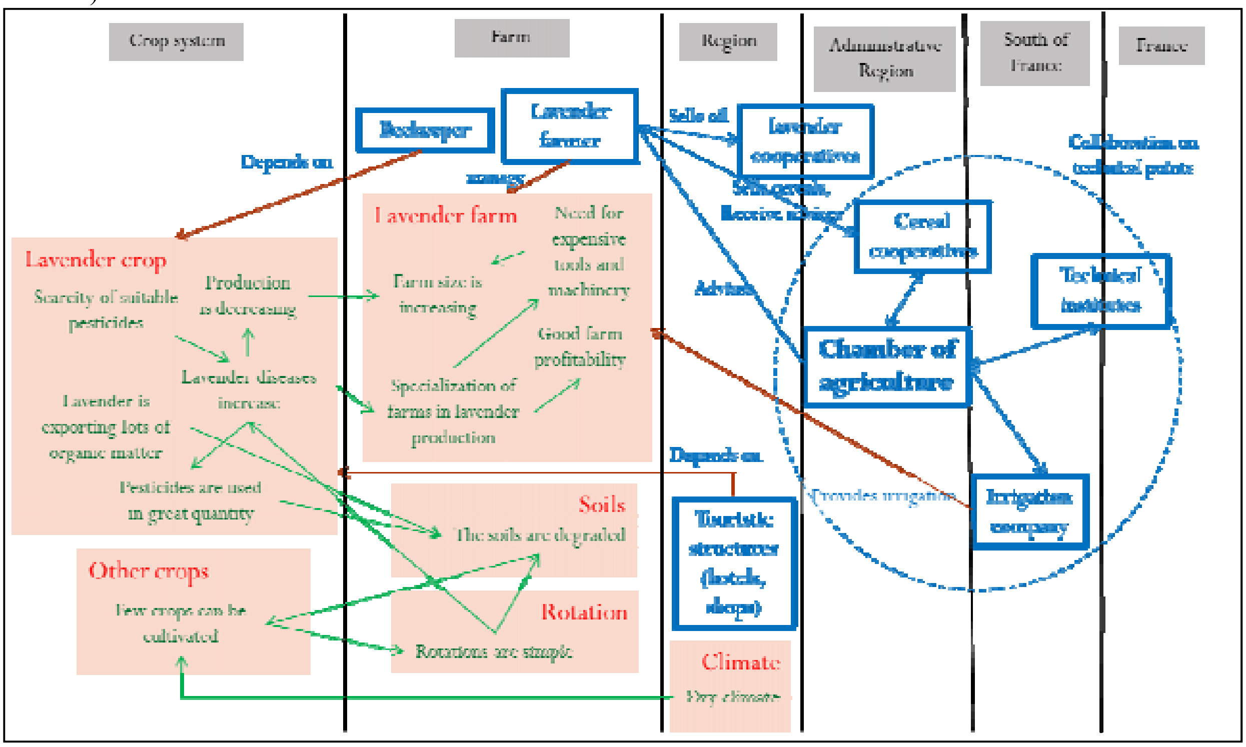
- **Comparison of CMs:** Final individual CMs will be compared to each other in order to contribute to the stakeholder analysis by the comparison of stakeholders' viewpoints. Comparison is based on (i) structural components, their nature (natural, agricultural or socio-economic) and definition scales; (ii) mentioned stakeholders and their scale of influence (iii) number of characteristics cited for each of the structural components or stakeholders; (iv) prioritization of the main issues. The comparison of the twenty maps will be done in automatized way thanks to the CmapTools® software.
- **Aggregation of CMs:** Individual CMs will be aggregated in a few thematic CMs conceptualizing the socio-ecological system. Structural components, their characteristics, and supply chain stakeholders will be represented. Thematic cognitive maps will be structured around specific issues or themes according to stakeholders concerns. The delimitation of clear objectives for the project, and the clarification of a relevant question on which it will focus, will guide these themes for thematic CMs. A thematic CM representing all relationships between stakeholders will also be developed as base for social network analysis.

Preliminary results

Building the CMs

An example of a CM is given in figure 2. This CM has been built from the interview of an agronomist working in an institution supporting agricultural extension (chamber of agriculture), and which is later referred to as 'stakeholder A'.

Figure 2: example of CM built from the interview of an agronomist from the local Chamber of agriculture (stakeholder A).



Crop system level
Stakeholder A mentioned two structural components at crop system level: the *lavender crop*, and the *other crops*. Five characteristics have been elicited for lavender crop, whose four are interrelated: the scarcity of suitable pesticides for lavender crop implies an increase of lavender diseases. These diseases have two consequences: the decrease of lavender production and the use of pesticides in great quantity. The fact that lavender impoverishes soil organic matter has also been elicited. All other crops appear as one sole structural component as stakeholder A didn't differentiate them during the interview. They have only one characteristic: except lavender, few crops are suitable for the region.

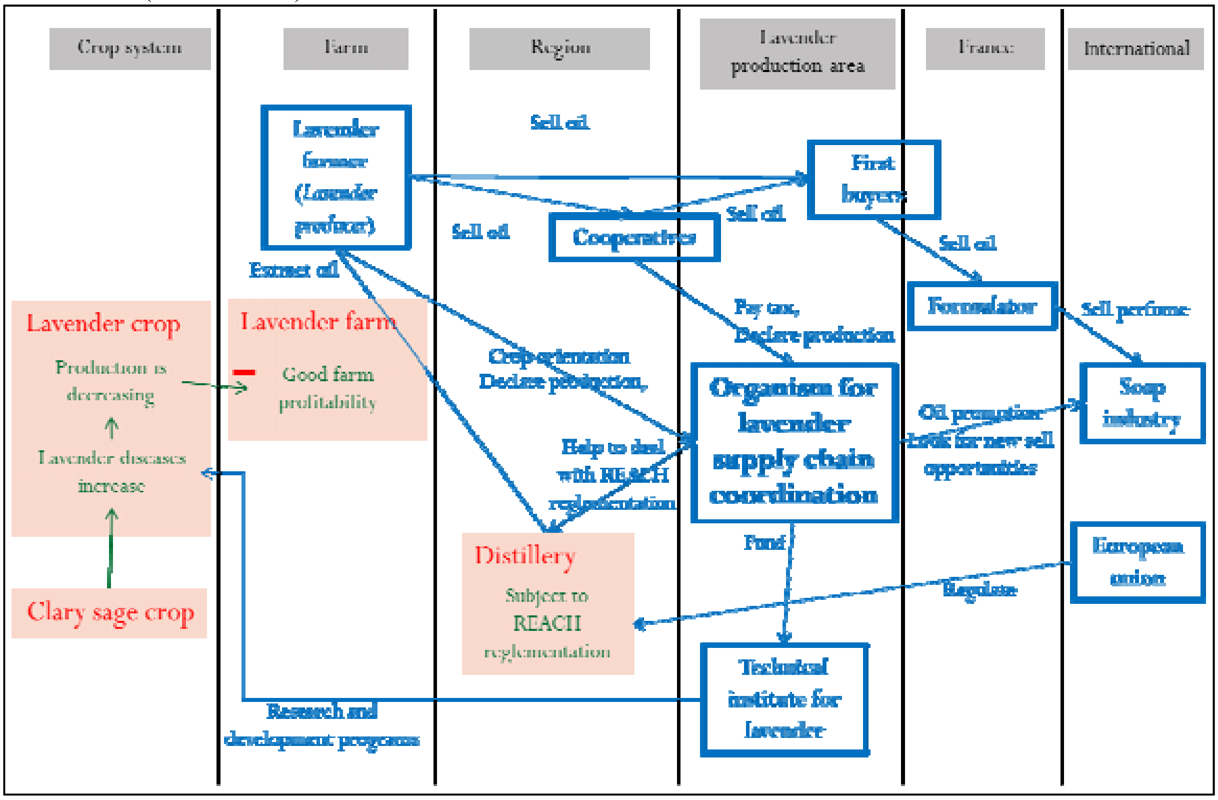
Farm level
Three structural components have been elicited at farm level: a socio-economic one (*lavender farm*), an agricultural one (*rotation*), and a natural resource (*soils*). Two stakeholders have also been mentioned: beekeepers who depend on lavender crops, and lavender farmers who manage lavender farms. Four characteristics have been elicited for a lavender farm: (1) the specialization of a farm in lavender production implies (2) good farm profitability, and also (3) the need for expensive tools and machinery. As a consequence, (4) farms increase in size, this dynamic being also due to the decrease of lavender production at lavender crop level. As lavender is the foundational crop of a lavender farm, a relationship has been elicited between those two structural components. One vicious circle is put in evidence through the relationships between crop rotations, soils, and the cultivated non-lavender species: the limited number of suitable crops creates a very simple rotation that is seen as a driver of soil degradation; the latter limiting the number of suitable crops. Soil degradation also has two causes at lavender crop level: the fact that lavender is exporting a lot of organic matter and the use of pesticides in great quantity.

Regions and country levels
Only one structural component has been identified at these scales: the climate. Dry climate is a limiting factor for cropping systems diversification. Lavender and cereals cooperatives have been elicited as supply chain stakeholders, as they are the purchasers of lavender farmers' production. Another stakeholder, widely named "touristic structures" has been identified at the regional scale, and is presented as dependent upon lavender crops. Stakeholders cooperating on technical aspects have been identified, namely the technical institutes, irrigation company, cereals cooperatives and the chamber of agriculture.

Analyzing the CMs

Diagnosis of the socio-ecological system
In order to illustrate how CMs can be compared, a second example of a CM is given in figure 3. This CM has been built from the interview of the head of an economic institution that aims to coordinate the lavender supply chain, later referred to as 'stakeholder B'.

Figure 3: Example of CM built from the interview of the head of an economic institution for lavender supply chain coordination (stakeholder b).



Stakeholder A has especially mentioned structural components, characteristics and dynamics occurring for agricultural systems. Two structural components have been deeply detailed in terms of characteristics: the lavender crops and the lavender farm. Relationships with other structural components, such as the soils, rotation or climate have been elicited.

Stakeholder B didn't offer as much detail on the agricultural systems: lavender crop and lavender farms have been cited, but their characteristics weren't emphasized. However, stakeholder B elicited another structural component at the crop system level, the clary sage crop, linked to the lavender crop through a positive effect on diseases. Stakeholder B's CM gives more information on stakeholders and their activities, eliciting the organization of the lavender supply chain. When stakeholder A only cited the cooperatives as supply chain stakeholders, stakeholder B mentioned the first buyers, the formulators and the soap industry. Relationships between those stakeholders have also been elicited: cooperatives tie lavender producers and first buyers, with the latter then selling oil to a formulator, who then sells to the soap industry. Those stakeholders have different supply areas: cooperatives usually collect oil at the regional level, while formulators work at a national scale. A new structural component linked to lavender supply chain appears: the distillery, which allows for oil extraction from lavender.

The comparison of those two maps therefore gives information about agricultural systems, thanks to stakeholder A's CM, but also about lavender supply chain, thanks to stakeholder B's CM. By aggregating those 2 CM, agronomical and economical data have been identified and can be synthesized into the socio-ecological system.

Stakeholder analysis

Comparing those two CMs also gives information on the *viewpoints* held by these two stakeholders. The structural components mentioned and the level of detail given for each of them, shows that they have different concerns about the socio-ecological system. For example, distillery has been mentioned only by stakeholder B, which shows that this structural component is source of interest for this stakeholder. On the contrary, stakeholder A did not mention it. Stakeholder A also gave a lot of technical details about lavender crops and how these influence the operation of lavender farms, highlighting the centrality of technical issues for this stakeholder. To the contrary, stakeholder B gave more information about supply chains and related stakeholders, showing that this stakeholder viewpoint is focalized on socio-economic issues.

The elicitation of the relationships between stakeholders contributes also to *social network analysis*. Figure 3 shows that stakeholder B's institution has strong relationships with lavender supply chain organizations (cooperatives, soap industry, distillery…) while stakeholder A is essentially in collaboration with technical structures (figure 2). Information is also given about relationships between other stakeholders. By aggregating the information of the two CMs, we can see that lavender cooperatives have relationships with lavender farmers, "first buyers" and the "organism for lavender supply chain coordination"; but that no relationship has been elicited with the chamber of agriculture. No relationship has also been elicited with the touristic structures, which would suggest that these stakeholders are isolated from the lavender production despite being dependent upon it. These preliminary results still have to be analyzed within the context of other stakeholders' CMs.

Discussions and perspectives

Contribution to the diagnosis of the socio-ecological system

Each CM is a specific representation of the socio-ecological system, based on a particular stakeholder's perspectives about the region. At a glance, it is possible to visualize structural components of the system, their characteristics and dynamics, and cause-effect relationships occurring within the system, allowing for a description of the system structure and of its dynamics. The formalization through representation at different spatial scales helps to show the links between different sub-systems operating at different levels (e.g. field, farm and supply chain). The relevant issues of the agricultural systems can be addressed through the main characteristics, and can be linked. This wide and systemic vision is important in methodologies aiming to have direct or indirect impact on agricultural management, in order to master all collateral consequences of action plans (Sattler et al., 2010).

The second step of the CLIMATAC project aims to develop a conceptual model at the farm and regional scale. This conceptual model will then be used in order to develop a model for participatory scenario assessment with stakeholders. It will be structured according to the delimitation of the objectives of the project and clarification of the question that is the focus of the continued research. The aggregated thematic CM could therefore be considered as a conceptual model of the system, to be discussed and improved during collective meetings with stakeholders, following the approach presented in Le Page et al. (2010) and Etienne et al. (2011). For this purpose, the utilization of these CMs during the initial diagnosis can also get the stakeholders familiarized with this kind of system representation.

Contribution to the stakeholder analysis

The method presented above has two main contributions in terms of stakeholder analysis. First, CMs can be considered as mental models of the stakeholders, and therefore used to elicit stakeholders' viewpoints. CM can be compared using quantitative analyses based on their structure, on the number and nature of elicited concepts or CM density, resulting in a stakeholder categorization (Özesmi & Özesmi, 2004). Such categorization can then be used in order to design the participation process, in order to ensure that all viewpoints are represented in the process. Moreover, this categorization can help the evaluation of the process, by the comparison of its impacts on the different types of stakeholders. Second, the aggregation of the CMs leads to a thematic CM representing the social network, through the synthesis of current relationships between stakeholders. Social network analysis are relevant tools for participatory process (Guérin Schneider et al., 2010). Indeed, they allow for following the evolution of relationships between stakeholders, and help to explain some stakeholders' behavior during the participatory process.

Influence of researcher on CMs

In this method, the CMs were built by a researcher from stakeholders' interviews. Biases are therefore important, as such the indirect elicitation method necessarily entails some simplifications (Edkins, 1998). A CM is an interpretation of the interview, rather than a sole graphical representation, the researcher's knowledge and vision influencing the CMs structure (Eden, 2004). Moreover, homogenization of the wordings of the concepts has been carried out in order to facilitate CMs aggregation, but can imply changes in word meaning. An example can be given by the utilization of the words "lavender producer" by the stakeholder B during the interview, when stakeholder A used the words "lavender farmer" (fig. 3). It shows differences in stakeholders visions, as stakeholder B used a term related to the supply chain and stakeholder A used a term related to the farming activity. We can consider that these two terms have the same meaning, and then replace "lavender producer" by "lavender farm", but such a change must be discussed with stakeholder B in order to avoid misunderstanding. Heterogeneity in interviews' duration (from one to two hours) also implies discrepancies when formalizing the concepts. However, to overcome these limitations, the maps were iteratively checked during their elaboration by the researcher to homogenize the mapping process. The integration of the validation step (step iii) suggested in the method aims to limit these biases, by giving the opportunity to the interviewee to modify the CM.

Conclusion

This paper presents a method to realize an initial diagnosis of the local context, as a preliminary step of a participatory research project targeting the sustainable development of agriculture at the regional level. This method contributes to the achievement of this diagnosis in two ways: (i) it contributes to the implementation of the project itself through the conceptualization of the socio-ecological system (ii) it contributes to the evaluation of this project through the stakeholder analysis. Implementation of the first two steps of this method in a region in the south-of-France showed that CM are a valuable tool for representing a diversity of knowledge, fields of activity, scales, and viewpoints represented by the interviewed stakeholders. This method therefore allows for simultaneously dealing with the two types of analysis, while most methodologies focus on only one of these aspects at a time.

The next steps of the project will allow for the verification of these maps with the interviewees to limit biases introduced by the fact that the maps were built by the researcher. CM will therefore have a new function: they will be used as an artefact in order to share information between the researcher and the interviewee. Through this boundary object, a representation of stakeholder's viewpoint, validated by the stakeholder and understood by the researcher will be possible.

References

Barnaud, C., Dumrongrojwatthana, P., Marie, J., Le Page, C. & Trébuil, G. (2006). Initial Analysis for Companion Modelling to Meet the Needs of Multiple Interests in Upper Watershed Management. Paper presented at Sustainable Sloping Lands and Watershed Management Conference. Luang Prabang, Laos, Becu, N. (2006). Identification et modélisation des représentations des acteurs locaux pour la gestion des bassins versants. Université de Montpellier 2,

Delmotte, S. (2011). Evaluation participative de scénarios: quelles perspectives pour les systèmes agricoles camarguais? Montpellier SupAgro,

Dray, A., Perez, P., Jones, N., Page, C. L., D'Aquino, P., White, I. & Auatabu, T. (2006). The AtollGame Experience: from Knowledge Engineering to a Computer-Assisted Role Playing Game. Journal of Artificial Societies & Social Simulation 9(1).

Eden, C. (2004). Analyzing cognitive maps to help structure issues or problems. European Journal of Operational Research 159(3): 673-686.

Edkins, A. (1998). A cognitive approach to exploring the management of the design process. London, University College London.

Etienne, M., Du Toit, D. R. & Pollard, S. (2011). ARDI: A Co-construction Method for Participatory Modeling in Natural Resources Management. Ecology and Society 16(1).

Fairweather, J. & Hunt, L. (2011). Can farmers map their farm system? Causal mapping and the sustainability of sheep/beef farms in New Zealand. Agriculture and Human Values 28(1): 55-66.

Faure, G., Gasselin, P., Triomphe, B., Temple, L. & Hocdé, H. (2010). Innover avec les acteurs du monde rural: la recherche-action en partenariat. Gembloux (Belgique), Quae.

Gouttenoire, L. (2010). Modéliser, partager, réinterroger. Une expérience participative pour accompagner les reconceptions de systèmes d'élevage. AgroParisTech, Paris

Grimble, R. & Wellard, K. (1997). Stakeholder methodologies in natural resource management: a review of principles, contexts, experiences and opportunities. Agricultural Systems 55(2): 173-193.

Guérin Schneider, L., Dionnet, M., Abrami, G. & Von Korff, Y. (2010). Comment évaluer les effets de la modélisation participative dans l'émergence d'une gouvernance territoriale. Recueil des communications du colloque OPDE 2010'aide à la décision et gouvernance'.

Hjortsø, C., Christensen, S. & Tarp, P. (2005). Rapid stakeholder and conflict assessment for natural resource management using cognitive mapping: The case of Damdoi Forest Enterprise, Vietnam. Agriculture and Human Values 22(2): 149-167.

Jésus, F. (2001). PACT A pro-active conciliation tool. Analysing Stakeholders' Inter-Relations-Monograph(41).

Jones, N. A., Ross, H., Lynam, T., Perez, P. & Leitch, A. (2011). Mental Models: An Interdisciplinary Synthesis of Theory and Methods. Ecology and Society 16(1).

Kosko, B. (1986). Fuzzy cognitive maps. International Journal of Man-Machine Studies 24(1): 65-75.

Le Page, C., Abrami, G., Barreteau, O., Becu, N., Bommel, P., Botta, A., Dray, A., Monteil, C. & Souchère, V. (2010). Des modèles pour partager des représentations. In La modélisation d'accompagnement: une démarche participative en appui au développement durable. M. Étienne, Quæ: 71-102.

Markoczy, L. & Goldberg, J. (1995). A method for eliciting and comparing causal maps. Journal of management 21(2): 305-333.

Mathevet, R., Antona, M., Barnaud, C., Fourage, C., Trébuil, G. & Aubert, S. (2010). Contextes et dépendances des processus d'accompagnement. In La modélisation d'accompagnement: une démarche participative en appui au développement durable. M. Etienne. Versailles, Quæ: 103-123.

Mathevet, R., Etienne, M., Lynam, T. & Calvet, C. (2011). Water Management in the Camargue Biosphere Reserve: Insights from Comparative Mental Models Analysis. Ecology and Society 16(1).

Mendoza, G. A. & Prabhu, R. (2006). Participatory modeling and analysis for sustainable forest management: Overview of soft system dynamics models and applications. Forest Policy and Economics 9(2): 179-196.

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-ecological Systems. Science 425(5939): 419-422.

Özesmi, U. & Özesmi, S. L. (2004). Ecological models based on people’s knowledge: a multi-step fuzzy cognitive mapping approach. Ecological Modelling 176(1): 43-64.

Prell, C., Hubacek, K. & Reed, M. (2009). Stakeholder analysis and social network analysis in natural resource management. Society and Natural Resources 22(6): 501-518.

Reed, M., Evely, A. C., Cundill, G., Fazey, I. R. A., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C. & Raymond, C. (2010). What is social learning? Ecology and Society.

Rossing, W. A. H., Zander, P., Josien, E., Groot, J. C. J., Meyer, B. C. & Knierim, A. (2007). Integrative modelling approaches for analysis of impact of multifunctional agriculture: A review for France, Germany and The Netherlands. Agriculture, Ecosystems & Environment 120(1): 41-57.

Sattler, C., Nagel, U. J., Werner, A. & Zander, P. (2010). Integrated assessment of agricultural production practices to enhance sustainable development in agricultural landscapes. Ecological Indicators 10(1): 49-61.

Schaffernicht, M. & Groesser, S. N. (2011). A comprehensive method for comparing mental models of dynamic systems. European Journal of Operational Research 210(1): 57-67.

van Kouwen, F., Schot, P. P. & Wassen, M. J. (2008). A framework for linking advanced simulation models with interactive cognitive maps. Environmental Modelling & Software 23(9): 1133-1144.

van Vliet, M., Kok, K. & Veldkamp, T. (2010). Linking stakeholders and modellers in scenario studies: The use of Fuzzy Cognitive Maps as a communication and learning tool. Futures 42(1): 1-14.

Vanwindekens, F. M., Stilmant, D. & Baret, P. V. (2013). Development of a broadened cognitive mapping approach for analysing systems of practices in social–ecological systems. Ecological Modelling 250: 352-362.