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Cognitive mapping, flemish beef farmers' perspectives and farm functioning: a critical methodological reflection

Louis Tessier[1,2] · Jo Bijttebier[1] · Fleur Marchand[1,3] · Philippe V. Baret[2]

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Abstract

In this paper we reflect on the effectiveness of cognitive mapping (CMing) as a method to study farm functioning in its complexity and its diverse forms in the framework of our own experiment with a diverse group of Flemish beef farmers. With a structured direct elicitation method we gathered 30 CMs. We analyzed the content of these maps both qualitatively and quantitatively. The central role of the concept "Income" in most maps indicated a shared concern for economic security. Further, the CMs indicated that farmers dealt with this shared social reality differently, as the relationships included in their maps referred to different functional processes relating to revenue streams, marketing strategies, investment decisions, dependence on production inputs, on-farm resource management, and personal well-being. With a clustering algorithm we grouped farmers based on the relationships in their maps, which allowed us to trace some of the broader patterns within the data, such as the existence of more business- and investment-minded farmers, in contrast to farmers focused on their quality of life, and animal production-oriented in contrast to marketing-oriented farmers. Taking into account farmers' comments, we find that the applied methods had limited capability to classify farmers based on their perspectives on farming. Still, the system presentations proved useful to study what aspects farmers were working on or towards, and how these aspects may actually fit together as a whole. CMing was therefore mostly effective in exploring farm functioning in its complexity, and less so in exploring farm functioning in its diversity.

Keywords Cognitive mapping · Livestock farming systems · Farmer agency · Critical realism

Abbreviation

CM Cognitive map

✉ Louis Tessier
louis.tessier@ilvo.vlaanderen.be

Jo Bijttebier
jo.bijttebier@ilvo.vlaanderen.be

Fleur Marchand
fleur.marchand@ilvo.vlaanderen.be

Philippe V. Baret
philippe.baret@uclouvain.be

1 Flanders Research Institute for Agriculture, Fisheries and Food, Social Science Unit, Burgemeester Van Gansberghelaan 115, 9820 Merelbeke, Belgium

2 Université catholique de Louvain, Earth and Life Institute, Sytra, Croix du Sud 2 / L7.05.05, 1348 Louvain-la-Neuve, Belgium

3 University of Antwerp, Institute of Environment and Sustainable Development, Groenenborgerlaan 171, 2020 Antwerpen, Belgium

Introduction

Transition of agricultural systems towards more sustainable agricultural practices would be greatly eased by sound intervention strategies and an appropriate governance of agricultural systems implemented at different institutional and spatial scales. The effectiveness of such strategies hinges on both a critical understanding of the social-ecological systems farmers are embedded in, and of farmers' situated self-understanding and behavior as key actors within these systems (Feola and Binder 2010). Empirical inquiry methods that can facilitate the development of such a critical interdisciplinary understanding are in high demand. The overall objective of this paper is to assess the effectiveness of cognitive mapping (CMing) as a method to study farm functioning in its complexity and its diverse forms in the framework of our own experiment with a diverse group of Flemish beef farmers.

CMing refers to a family of semi-qualitative methods to obtain and condense actors' beliefs about a system of interest into directed graphs consisting of defined variables (nodes) and relationships between these variables (edges). CMing methods have increasingly been used over the years in the agricultural sciences to solve all kinds of "wicked problems" researchers are confronted with (Christen et al. 2015). Farms are now commonly conceptualized as complex systems, consisting of human, technical and natural components, with their many linear and non-linear interrelations in between these components (Restrepo et al. 2014). System diagrams are in that regard fitting to visualize this conceptualization of farms, and CMing methods in particular has come to the attention as one of such methods, because the obtained directed graphs, can be used as ecological or bio-economic models to simulate system dynamics quantitatively (Özesmi and Özesmi 2004). Studies of this kind which included farmers as key informants, have for example sought to model late blight control systems in potato production in the Netherlands (Pacilly et al. 2016), grass forage management systems in Belgium (Vanwindekens et al. 2014), and cotton yield management systems in Greece (Papageorgiou et al. 2009). Yet, CMing has also gained currency within the agricultural sciences for a rather different analytical purpose, namely to study the beliefs of stakeholders themselves about a particular problem or situation. Studies of this kind include explorations on the views of different stakeholder groups on water management in the Camargue reserve in France (Mathevet et al. 2011), decision making processes regarding the uptake of agroecological practices by vineyard growers in Italy (Garini et al. 2017), and investment decision making in peri-urban South Ontario, Canada (Akimowicz et al. 2016).

It struck us, however, that even though CMing had been successfully used to model system dynamics and also to analyze actors' perspectives themselves (Ditzler et al. 2018), the use and interpretation of CMs for analytical purposes has been rather one-sided. Namely, 'hard' (the biological and technological components) and 'soft'(the meanings that actors give to these components) sides of farm functioning are studied separately rather than integrated. To overcome this separation of technical and social aspects of farm functioning, and the one-sided interpretation of CMs that it encourages, we put forward in this paper an affirmative but cautious perspective on CMing mapping as useful method to study farm functioning, which is informed mainly by critical realist philosophy[1] (Archer et al. 1998; Danermark et al. 2019). In our view, models created with systems methodologies such as CMs need first of all be taken as hermeneutical enablers to help structure debate about certain issues, rather than as a blue-print of a phenomenon 'out there' (Jackson 2001). While these may refer to this intransitive dimension of reality, they are necessarily incomplete and inaccurate models. This is not only because participants' subjective misconceptions and biases about reality are built into the map, but also because of the influence of a double hermeneutic that necessarily develops during elicitation itself (a term used in cognitive science to describe the process of inquiry to encourage a person to externalize a mental model). Just as a researcher tries to understand the world of the people s/he studies, the people being studied try and understand the motives and intentions of the researcher and the purpose of the research setting generally, and thus modify their behavior (Nuijten 2011). So even though stakeholders may appear to capture the situation so well, a functionalist over-appreciation of these models as adequately representing real-world phenomena needs to be resisted (Jackson 2001). Furthermore, it is necessary to recognize that beliefs about farm functioning, and farm functioning itself are ontologically distinct. While the concept of social-ecological systems emphasizes that the nature in these systems is socially produced and thus dependent on the concepts employed by human agents embedded in these systems, the components within such systems are not exhausted by the discourses about them (Zachariadis et al. 2013). It is therefore required from scientists to postulate the existence of real entities and objective social structures with causal powers of their own, which may have influenced an actor's representation of a system. This being said, CMs constructed by farmers about their farm are likely to be useful hermeneutical enablers for scientific inquiry into the functioning of farming systems, given that farmers are not only privileged witnesses of these processes day in, day out, but also because they are part of these processes through their agency as main decision makers within these systems.

This rest of this paper is organized as follows: after a short presentation of context and aim of the CMing experiment on which our reflection on CMing will be based, we discuss the different elicitation methods operationalized in the agricultural sciences, as well as the different analysis methods. In the section that follows we present the method of data gathering and analysis of our experiment with Flemish beef farmers. Then we describe the results of the application of the devised method. In the Discussion section we

[1] Critical realist philosophy is according to multiple authors (Jansen 2009; Nuijten 2011; Koutsouris 2012) a more adequate philosophical foundation for the application of systems methodologies in the agricultural sciences. Critical realism helped us to analytically distinguish between systems representations, the actual beliefs of farmers and their farms, which we put forward in this paper. Critical realism also heavily informed the assumptions we make throughout this paper about the existence of a concept-depended yet not concept-exhausted social world. Critical Realism indeed provides a sophisticated account about the nature of natural and social entities and mechanisms, and how they give rise to actual events and experience. In this paper we don't attempt, a systematic assessment of CMing from a critical realist perspective. For this mostly methodologically oriented paper, our discussion remains mostly at the level of experience and actual events. For accessible introductions to critical realism and its implications for interdisciplinary and social scientific research see Bhaskar et al. (2018) and Danermark et al. (2019), respectively.

come back to the overall objective of this paper, by discussing in depth whether the devised and applied CM method was effective in bringing insights about farm functioning.

Context of the presented experiment

This study was conducted within the frame of a wider research aiming at exploring the relevance of agroecology to beef farming in Flanders, Belgium. Flemish beef farmers find themselves more and more in search of alternative pathways, as the traditional prospects of further production intensification and scale enlargement are closing off in this densely populated and affluent region (Platteau et al. 2018). Though Flemish beef farmers may take all kind of actions to pursue agroecological principles (Tessier et al. 2020), we found that individual farmers may pursue these principles to a rather different extent or in a different way (Tessier et al. 2021). In order to account, however, for this observed diversity in practices, there is a need to understand whether these farming systems function differently, *i. e.* whether different processes varyingly sustain these farms as a whole, including the role of farmers' perspectives herein. Anticipating this challenge, and considering the arguments made in previous section, CMing appeared to us a suitable method of inquiry for this purpose.

Concomitantly, the selection of farmers for the presented CMing experiment was also driven by this broader objective. As we aimed exploring the full scope of agroecological practices on Flemish beef farms, we sought to obtain a sample of beef farmers diverse in their agricultural and marketing practices, rather than a representative sample of the beef farming population or subpopulations of it (*cfr.* Tessier et al. 2020). Therefore we selected farmers along the range of three axes: organic/conventional, direct sale of meat or not, specialized beef production or more mixed agricultural activities. To further increase the diversity in management practices in our sample, we complemented the data gathering with a variational sampling approach by contacting farmers of potential interest based on previous interview experiences.

Methodology

Our review of numerous recent CMing studies, which seek to capture farmers' beliefs on various aspects of their living environment, delivered an inventory of methods used to obtain CMs. This is reminiscent of the fact that across disciplines, despite the widespread popularity of these techniques, no consensus has formed within literature as to the most appropriate way to elicit CMs in general (Hodgkinson et al. 2004; Van Winsen et al. 2013). One commonly distinguishes between (i) indirect elicitation procedures, where the researcher is required to re-create or infer the network of concepts and edges from an oral interview or from questionnaire data (*e. g.* Vanwindekens et al. 2013; Van Winsen et al. 2013) and (ii) direct elicitation procedures, where a network representation of a mental model is directly elicited from the interviewee through a diagrammatic interview or drawn by the interviewee him or herself (Jones et al. 2011). Indirect elicitation methods are by their very nature unstructured, and depend heavily on the researcher's interpretation of what was said by the farmer. This is less the case with direct elicitation methods, but here again, two approaches are available. Either one lets the respondents come up with their own concepts to form a causal map (semi-structured) (*e. g.* Christen et al. 2015; Bosma et al. 2017) or the researcher provides a list of concepts a priori established (structured) (*e. g.* Fairweather and Hunt 2011; Akimowicz et al. 2016). The main disadvantage of structured methods is that it precludes the elicitation of novel constructs. This constrains the participants ability to represent the situation, potentially forcing an alien conceptual framework onto farmers. The upshot is that the elicitation process can be better controlled by the researcher as the respondents are presented by the same conceptual stimuli. Furthermore, by using identically worded factors direct comparison of maps can be carried out, without the researcher having to decide whether two similarly worded factors are the same (Markóczy and Goldberg 1995). As a result, one chooses to deal with the inevitable coding problem prior to elicitation as opposed to after elicitation, which simplifies further analysis. To elicit the causal relations in structured direct elicitation two contrasting techniques have been adopted for direct elicitation: the use of relatively intensive methods involving pairwise judgments of causal relationships and techniques that seek to capture participants' causal belief systems directly in a visual form. The former category of procedures uses implications grids or structured questionnaires. The latter category includes approaches whereby participants represent their causal belief systems using a hand-drawn paper-and-pencil procedure. Hodgkinson et al. (2004) compared the two methods and found that the latter free-hand method was more likely to elicit too few relations and concepts (omission), while the pairwise comparison techniques was more likely to elicit too many or irrelevant relations (commission). We could conclude that such method issues of 'memory error' are inherently part of the elicitation process.

Independently of the elicitation method chosen, the attractiveness of CMing for social-ecological systems researchers is their compatibility with adjacency matrices for further quantitative inquiry. Many CM studies in agricultural sciences have used quantitative methods indeed (calculation of steady-state values, simulation of scenario's) to uncover how system components and processes may affect one another, or used quantitative techniques to classify and compare stakeholders' perceptions of a similar system (Vanwindekens et al. 2014; Ditzler et al. 2018). In critical realism, the predictive use of mathematical models is discouraged on ontological grounds, particularly for approximating the dynamics of 'open systems' such as farming systems (Jansen 2009). Nonetheless, the patterns revealed by quantitative analyses can play a significant part in developing propositions about existing causal mechanisms, and can help to assess and explain the results in the analysis phase. (Zachariadis et al. 2013). Furthermore, disentangling differences in perceptions of farm functioning from actual farm functioning, requires to take into account the context in which each of these maps arose. In fact, we observe that qualitative information such as interviewees remarks, field notes and observations made during the elicitation process was often instrumental in interpreting and discussing the obtained maps.

In considering the aim of our empirical study at the time, namely to identify the different processes that may varyingly sustain Flemish beef farms as a whole, we spotted a trade-off between considerations of practical nature (feasibility given limited research resources and demands on participants' time and mapping abilities) and analytical nature (our capacity to use CMs to identify system dynamics of interest and farmers' perceptions of these). These considerations led us to prefer a direct structured elicitation with the free-hand technique. In our estimation this approach would place tolerable demands on the farmers' time and cognitive abilities, while allowing farmers to communicate their own causal beliefs with limited involvement of the researcher. Our preference for the free-hand method was mainly practical, as we were concerned that participants might find the task too difficult and insufficiently engaging. Considering the arguments above, we hypothesized that a mixed method of analysis may maximize our chances of addressing both issues of feasibility and analytical utility. That is by using a limited set of quantitative techniques to identify general patterns within the data, and to contextualize and interpret these patterns through qualitative analysis of the comments made by farmers during elicitation.

Materials and methods

The developed method consists out of three steps: (i) a preparatory step consisting of concept pool construction and pilot interviews, (ii) data gathering including both the physical maps as well as an audio recording of the whole elicitation process and (iii) an analysis step in which explored the content of the maps in light of the comments made by the farmers with mixed methods.

Preparatory step

For structured elicitation methods a concept pool has to be created for interviewees to draw and construct their mental model. This concept pool should consist of concepts that are variable, unambiguously understood, unduplicated and cover multiple aspects of farming. We took inspiration from a study conducted by Bijttebier et al. (2016), who identified relevant factors influencing farmer's decision making, based on seven interviews with organic beef farmers in Flanders, and from the concept pool constructed by Fairweather and Hunt (2011) used for CMing with dairy farmers in New Zealand. Straight-up copying of these concept pools wasn't possible, however, as both studies put forward many non-variable concepts, which is problematic for effective causal mapping (*cfr.* Nakamura et al. 1982). The preliminary concept pool contained 63 variables and we tested this concept pool in four pilot interviews (one with organic direct selling farmers, and three with conventional whole-selling farmers). Based on this initial experience, we slightly adjusted the elicitation procedure, and constructed through merging, reformulating and scrapping of initial concepts, a list of 48 concepts (Table 1).

Data gathering

As a way of social introduction and in order to familiarize ourselves with each situation, we asked a series of open-ended questions on the farm's history, current agricultural activities, perceived strengths and weaknesses of the farm, and their future perspectives. CMs were then obtained as follows: first, we explained how to draw a CM by using an unrelated map, then we asked the farmer(s) to sort all the concepts into three piles: one for the factors important to their farming system, one for the factors unimportant in their farming system and the remainder for the factors that were of some importance in their farming system. Then we asked the farmer to select post-it's from the important pile and put these on a piece of A2 paper. Once about four concepts were chosen, we gave the farmer(s) a pen and we asked to draw the signed (±) causal connections between those concepts in order to show how they are related. Next, farmers built up their causal map by adding in concepts of any pile, up to 20 concepts. During the process we reminded farmers to consider each concept for what it causes and, in turn, what causes it. When a respondent appeared to have difficulties drawing relations, we resorted to propositional statements such as "*does this concept influence this concept?*", or "*is this concept related to this concept?*" as well as inquiring statement such as "*so if this concept improves, this decreases?*", particularly when edges were drawn that seemed inconsistent with what the farmer(s) had expressed verbally. During the elicitation, farmers were encouraged

Table 1 Translated list of concepts used for CMing. Concepts are grouped interpretively: internal economic decision making (yellow), external social relations (blue), soil and environment (brown), plant production related (green), animal production related (red), daily farm life experience (purple). (For interpretation of the references to color in this table description, the reader is referred to the web version of this article.)

Accounting/Administration	Product and Sale Channel Diversity	Animal Diseases, Plagues and Deaths
Available Land	Regional Embeddedness	Animal Handling and Welfare
Business Expansion	Regulatory Requirements	Animal Resilience
Continuity Enterprise/ Succession	Subsidies	Hygiene and Food Security
Debt	Biodiversity	Meat Quality
Income	Nutrient Emissions and Losses	Medical Interventions
Investments	Renewable Energy	Other Livestock
Stable Infrastructure	Soil Cultivation	Share of Concentrates in Ration
Technical Innovation	Soil Organic Matter	Stocking Rate
Contact with Consumers	Use of Manure	Technical Results
Co-operation with other Farmers	Buying Fodder	Total Yearly Animal Production
Direct Sale	Cash Crops	Activities outside Agriculture
Firm Image	Crop Diversity in Time and Space	Autonomy
Hired Labor	Fertilizer	Leisure
Knowledge Network	Pesticides	Satisfaction
Pricing	Roughage Quality	Work Pressure

to comment and explain their thought process. The full exchange was recorded for each case and transcribed.

Analysis methods

For the purposes of complementarity and compensation, we used both quantitative and qualitative methods to characterize and compare the content of the processed CMs (Zachariadis et al. 2013).

Qualitative content analysis and processing

Our qualitative analysis had two purposes: to identify the meanings attached to concepts and relationships included in the maps, and to check the consistency of the drawn maps with farmers' stated beliefs in order to prepare them for further quantitative analysis. Some farmers were mostly silent during elicitation. This compelled us to focus on the part of the data that was gathered most systematically from the farmers, namely the information contained in the physical maps. Nonetheless, we interpreted these patterns in the light of the comments farmers made during elicitation. The combination of both sources deliver a more complete picture from which to make inferences about what farmers sought to represent with the relations they drew and why so. In an inductive and iterative manner, we conceptualized functional processes which refer to particular meanings farmers attached to the relations they drew, and kept track of the maps and the relations the functional processes referred to on a spreadsheet. To explore the content of the CMs quantitatively, we had to convert the maps drawn by farmers, into adjacency matrices. The resulting matrices are a combination of both the maps drawn by the farmers and the transcripts of the audio records. This combination is supported by following observations: farmers were regularly drawing edges implying relationship which were in conflict with their descriptions of these relations; and farmers often used correlational rather than causal language to describe relations between concepts, leading them to be rather imprecise at times about the orientation of the edges. Combining both maps and records allowed us to assess the consistency between both in order to create matrices optimally representing farmers' perspectives on farm functioning.

Quantitative descriptive and comparative analysis

We computed several graph theoretical metrics relating to the structure of the maps (number of nodes, number of

Table 2 Distribution of cases along the three a priori axes used for theoretical sampling: Organic (or transitioning) to Organic or not; Direct Sale of meat or not; Diversified Agricultural Activities, defined here as rearing other livestock species than bovines for Sale or growing cash crops excluding wheat

Organic or transitioning to organic?	Direct sale of meat?	Diversified agricultural activities?	Number of cases participating	Number of maps Retained
Yes	Yes	Yes	9	7
		No	1	1
	No	Yes	1	1
		No	0	0
No	Yes	Yes	4	3
		No	4	3
	No	Yes	13	12
		No	3	3

edges), as well as the components of these maps (concepts and relations included, out-degree, in-degree, centrality of concepts). Computation of these metrics was done in the R programming environment using the functions implemented in the FCMapper package, developed originally for Microsoft Excel (Bachhofer and Wildenberg 2011). We quantified the content difference between individual CMs based on the generalized Distance ratio Formula as described by Markóczy and Goldberg (1995). This formula developed by Langfield-Smith and Wirth (1992) combines various distance measures, which include differences in strengths of common communicated causal beliefs, the differences due to the existence or non-existence of such relations involving common concepts, and the difference due to such relations consisting of unique elements. With a hierarchical agglomerative clustering algorithm using the Ward's minimum variance method as linkage criterion, and with the distance measures as inputs, we generated a Tree plot diagram generated, on which basis clusters of farmers were identified. By aggregating the maps of farmers classified in each cluster, we created group maps. These maps were visualized and compared in terms of the included relations, the centrality of the concepts, and the functional processes referred to by the farmers.

We concluded our analysis by assessing the homogeneity of clusters identified quantitatively by considering the comments that these farmers had made on their map and their outlook on farming that could explain farmers being part of one cluster and not another.

Results and analysis

For this study we conducted 35 interviews with beef farmers, aside from the four pilot interviews (Table 2). We decided to exclude five interviews from further analysis: in two cases, the circumstances for mapping were unfavorable (in one case the farmer was clearly too tired, and in the other case the mapping was interrupted by the entry of a family member, who hijacked the interview), and in the other three cases, farmers drew interactions between groups of concepts rather than individual concepts, making it impossible to transform these maps into adjacency matrices needed to apply the chosen quantitative methods. Still, the 30 remaining maps were successfully converted into adjacency matrices, after we changed in total 73 relations and six concepts, so that these were in accordance with what farmers were saying about their relations in the map while they were mapping. Of these 30 maps, 23 were elicited from individual farmers (18 men, five women). The other seven maps were elicited from two or three members of the household from both sexes.

These CMs included in total 331 different non-zero relations connecting all but one concept ("Nutrient Losses and Emission") to a varying degree. Individual maps after processing differ markedly in elaborateness with on average 14.8 ± 2.8 Std concepts, and 21.0 ± 4.6 Std connections (Fig. 1), but also in terms of the kind of concepts they include. Some farmers extensively drew on concepts related to "Animal Production" to communicate what was important to them about their farm, whereas others mainly integrated concepts related to "External Social Relations" or use many concepts from the "Internal Economic Decision Making". The aspects "Plant Production", "Soil and Environment" and "Daily Life Experience" are less consistently included by farmers in their map. Many farmers said they could include many more concepts, though only two farmers effectively reached the 20 concepts allowed. Some farmers said that it would become a tedious affair or that it would take too much time to integrate more concepts, or that it was better to stick with the most important concepts.

Figure 2 shows the number of times concepts were integrated in the maps, and the average of centrality scores for these concepts, in all maps, and in those maps including the corresponding concepts. The concept "Income" stands out for all of these metrics, with 27 farmers including it in their map, and with 5.5 edges on average overall going from and to it. The next three most included concepts ("Meat Quality", "Pricing", "Satisfaction") play a markedly less central

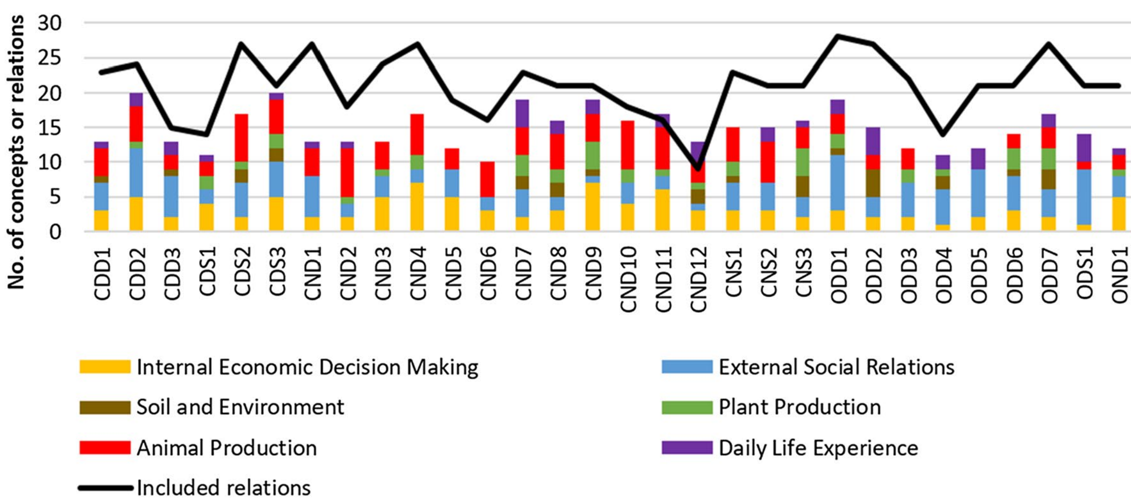

Fig. 1 Average centrality scores of concepts in the maps containing them and overall on average, sorted by times included by farmers. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

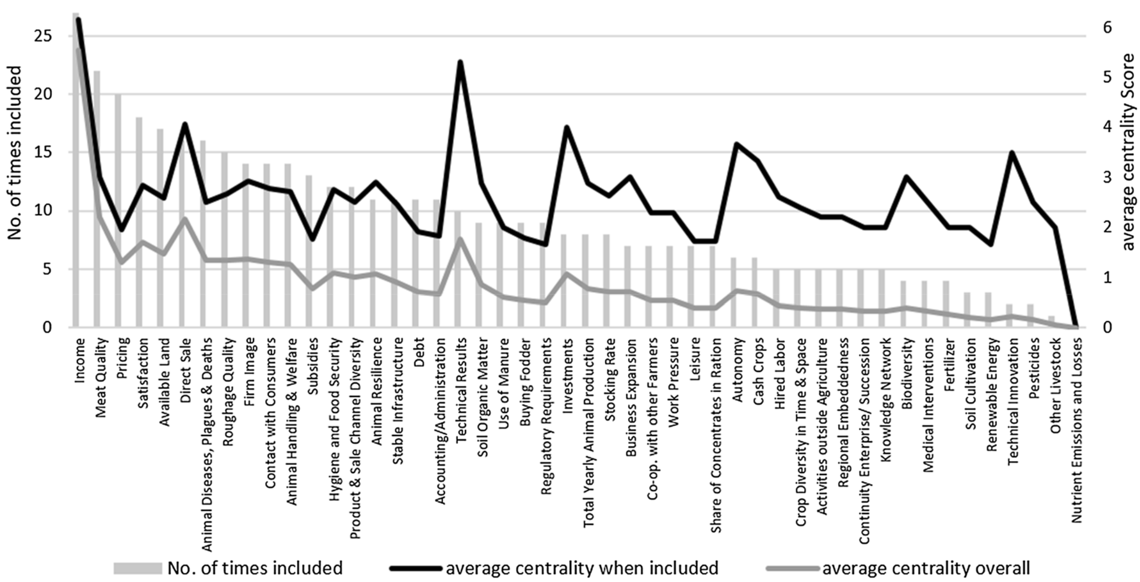

Fig. 2 Chart showing the final number concepts, sorted by their respective concept groups into stacked bars, and final number of relations included (black line) in each individual CM. Cases sorted by label: (O–) organic, (C–) conventional, (–D–) direct sale of meat or (–N–) no direct sale of meat, (–S) specialized beef production or (–D) more mixed agricultural activities

role in the maps on average, compared to "Income". A couple of concepts, particularly "Technical Results", but also "Direct Sale", "Investments", "Autonomy", "Technical Innovation" and "Cash Crops"), differ from other concepts as they are less regularly included in the maps, but when they are, they do play a central role in those maps.

While there are considerable content differences between maps, as Figs. 1 and 2 show, we observe the frequent and central role of "Income" in the overwhelming majority of individual maps. "Income" indeed appears to be the main reference point for farmers to assess what concepts are worthwhile to consider integrating in their systems, and farmers also frequently verbally noted that this was the most important concept in their map. "*Eventually, that's what we do it for. Working to have a good income and a good life, and if you have a good income, then you can work on your leisure, and your quality, and whatever else.*" (CNS2). While some maps present a system in which "Income" is the only end, it figures often as a means for the pursuit of autonomy, satisfaction, social standing, business expansion, paying off debts or generational succession. This suggests that farming systems are at least in part, driven by other motives than

Table 3 Relations corresponding with functional processes "set-up/improve direct sale activities on your own"

Set up/improve direct sale activities on your own	contact with consumers → firm image → product and sale channel diversity; meat quality → direct sale ↔ income (3x); meat quality → direct sale ← cash crops; meat quality → direct sale → contact with consumers; business expansion → direct sale → contact with consumers; autonomy ← direct sale → pricing; direct sale → contact with consumers → firm image; autonomy → direct sale → contact with consumers; co-op with other farmers → contact with consumers → product and sale channels diversity; income ↔ contact with consumers → direct sale; direct sale → pricing; firm image → contact with consumers ↔ direct sale;

maximizing income. In three maps, "Income" isn't even included, which suggest that in some cases lack of income may be less pressing or more acceptable, such as would be the case in non-commercial farming, that farmers are less involved in farm financial matters personally, or that income generation shouldn't play in the mind of these farmers a role. Still, exclusion of "Income" may also derive from a belief that gaining an income is so self-evident that it doesn't have to figure on the map. As one farmer (CND6), who did not include "Income" in her map but instead organized concepts around "Animal Handling & Welfare", put it: "*Without income you can't go further, but we are a bit older, and have some room to do something else. But if your* [animal] *welfare is good, then you'll have good results too. Without putting your heart and soul in it, it won't work."* From this we may conclude that generally speaking continued income generation is presented by farmers as a necessary and system defining functional process on their farm. As further analysis of the comments in conjunction with the maps indicate, however, income generation is not the only process that is communicated by farmers to be important.

By examining the maps and the comments made by farmers next to each other we found that farmers often expressed similar ideas, but that these could be expressed through different concepts and relations. For instance, we find that out of the 20 maps which contain both the concepts "Income" and "Meat Quality", six contain a direct relation between these two concepts, whereas four others contain the indirect relation "Meat Quality → "Pricing" → "Income". Based on the comments made by these farmers, however, we have no reason to believe that these farmers were actually conveying a different idea with these different relations. Furthermore, some concepts were used interchangeably. This was most clearly the case for the concepts "Direct Sale" and "Contact with Consumers", where we found that either or both of these concepts were used by farmers to describe the activity of selling their own produce to consumers themselves. Other pairs of interchangeably used concepts include "Diversity of Species in Time and Space" and "Diversity of Products and Sale Channels", "Leisure" and "Activities Outside of Agriculture", and "Animal Diseases, Plagues & Deaths" as a negative substitute for "Animal Welfare and Handling". Yet, we also found that similar concepts and relations could have rather different meanings attributed to them. For instance, while most farmers interpreted "Direct Sale" as selling directly to consumers, some farmers used this concept to refer to the activity of selling agricultural products to a restaurant (CND2) or a supermarket chain (CND5), as opposed to a cattle trader or a meat processing company.

Through qualitative analysis of the digital visualizations of individual maps, along with the statements made by farmers during elicitation, we identified 35 functional processes referred by these 30 farmers. Some of these functional processes refer to a specific relation or specific combination of relations, such as for instance the functional process "Renewable Energy for revenue", which is specifically tied to the relation "Renewable Energy → Income". However, most of the functional processes were recognizable in multiple sets of relations drawn by individual farmers, and often require the additional information provided by the recordings to correctly categorize. Table 3 illustrates this phenomenon for one such functional process.

We grouped these 35 functional processes in six categories for heuristic purposes: (i) the procurement of monetary means generally and through various revenue streams in particular, (ii) marketing strategies, (iii) the procurement of physical inputs, (iv) investment strategies, (v) management strategies to improve the internal flows of these resources, and (vi) experiences of the farmer as manager and worker in this whole. On average, farmers referred to 9.8 ± 2.0 Std functional processes in their map and share between zero and nine functional processes with other maps, with an average of 3.7. We find that almost two-thirds of the farmers expressed in one way or another that they sought to differentiate themselves by the particular characteristics of their products, whereas exactly half of the farmers referred to "setting up or improving direct selling activities on your own to consumers", and to "other things than income brought satisfaction". Ten other functional processes were also referred to by at least a third of the farmers in their maps. Table 4

Table 4 Functional processes represented in the maps of each farmer grouped by cluster, based on qualitative analysis

		1									2					3								4								
		OND1	CND5	CND1	CDD3	ODD1	CDS1	CNS1	ODD3	CDD1	ODD6	ODD5	ODS1	ODD2	ODD4	CDS2	ODD7	CDS3	CND8	CND12	CNS3	CND7	CND9	CND3	CDD2	CND2	CNS2	CND11	CND6	CND4	CND10	TOTAL
revenu streams	Improve/maintain income	1	1	1	1	1	1	1	1	1		1	1		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	27
	Get subsidies				1	1						1				1	1	1	1			1		1					1	1	1	12
	Crop production for sale	1							1		1						1	1				1	1							1		8
	Other remunerating activities				1	1							1										1									4
	Revenue from renewable energy				1					1												1										3
	Nature conservation					1																										1
extern. social relatio	Commercial advantage through qualities of the product	1	1	1	1			1	1	1			1			1	1	1		1	1	1	1			1	1	1			1	19
	Set up/improve direct sale activities independently			1	1	1	1		1	1	1	1	1	1	1	1	1	1							1							15
	Set up/ improve alternative chain independently			1	1							1	1	1			1				1				1	1	1					10
	Commercial advantage through qualities of the firm			1		1	1	1	1	1						1					1				1							9
	Co-operation in alternative chain		1							1			1		1																	4
	Negotiate in whole-chain	1																	1													2
	Make publicity in supermarkets							1																								1
inputs	Re-Use Biomass							1		1	1			1	1	1	1	1	1	1	1		1									12
	Reduce dependence on off-farm fodder					1			1		1	1						1			1		1	1	1	1						10
	Establish partnerships for production factors					1			1		1				1																	4
	Increase output with bought feeds, pesticides, fertilizers,																					1								1	1	3
investment	Increase scale animal production		1					1			1								1	1			1	1			1	1		1		10
	Reduce debts/maintain financial autonomy					1									1			1	1	1	1		1				1					8
	Invest in stable infrastructure and technical innovation	1	1	1																			1		1				1	1	1	8
	Debt Finance Investments	1	1																											1		3
intern. resource manageme	Isolate from and eradicate pests and treat diseases				1		1	1								1						1	1		1	1	1		1	1	1	12
	Use knowledge of financial and technical results	1					1												1					1	1	1	1	1	1	1	1	11
	Improve technical results	1				1				1									1					1	1	1	1	1	1			10
	Integrated soil management										1			1	1	1	1	1	1	1												8
	Healthy housing conditions		1				1	1								1										1		1			1	7
	Resilience and welfare through feed					1	1		1								1	1	1													6
	Prod. diversification for techn. or commercial advantages										1			1	1	1	1		1													6
	Make use or build a knowledge network					1							1					1						1	1							5
	Graze more extensively				1		1			1	1																			1		5
pers. experienc	Other things bring satisfaction				1		1			1		1	1	1	1		1	1	1		1	1				1	1	1				15
	Income gives satisfaction			1	1		1					1	1		1				1		1	1			1		1					11
	Balance workload											1	1	1			1		1	1		1	1		1		1	1				11
	Regulations hamper progress/vision							1			1	1			1							1		1	1		1					8
	Satisfaction is instrumental						1			1										1					1	1						5

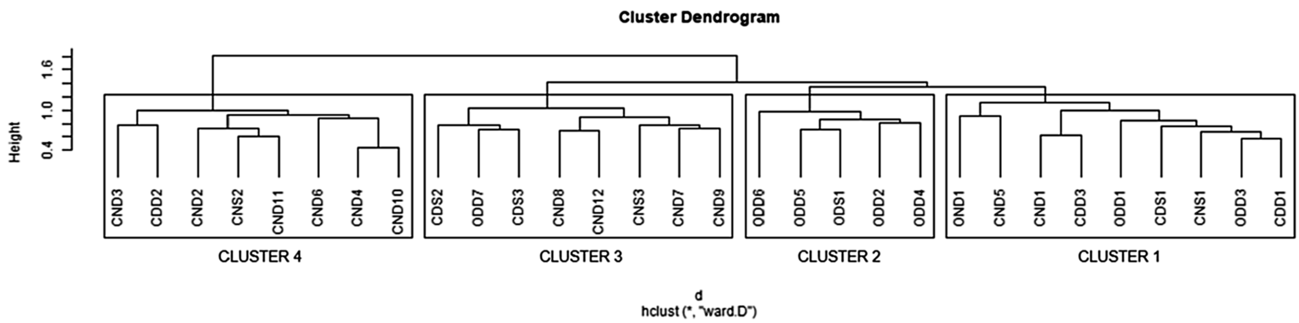

Fig. 3 Tree-Plot diagram created based on Hierarchical Agglomerative Clustering of cases based on the similarity of maps based on the general Distance Formula, using the Ward's Minimum Variance method

gives an overview of the functional processes referred to in each map.

Figure 3 shows the tree-plot diagram which was generated after hierarchical cluster analysis of adjacency matrices. This algorithm compared the similarity of the maps based on the Langfield-Smith and Wirth's (1992) general distance measure, and then selected in an iterative manner similar maps for clustering with the Ward's minimum Variance method as linkage criterion. The tree-plot diagram shows that a good part of the overall variability among the maps can be explained by the existence of more homogeneous groups of maps in terms of concepts and relations included within maps. The labeling of these separate branches, based on the a priori categorization criteria, shows that farmers of a similar type also drew maps that are quite similar in content, as far as the distance measure for clustering is concerned. Based on inspection of this tree-plot we selected four as the appropriate number of clusters. Notwithstanding the smaller distance between clustered individual maps, the proportionately high within cluster error of the lower-level clusters (visualized by the long initial stalks of the tree) indicates that even maps closest to each other don't overlap for a large share of the relations and concepts that they include. In fact, maps only share a maximum of 13 concepts with other maps, 5.8 on average, and a maximum of 7 non-zero relations, 1.9 non-zero relations on average, and only 126 out of the 331 different relations was drawn more than once.

While there is significant within-cluster heterogeneity, we find that the maps of these farmers classified by the applied clustering algorithm have a shared content, both in terms of the concepts and relations included (Fig. 4), and in terms of the meanings attributed to these included relationships (Table 4).

- The most distinct group of farmers (cluster 4) based on the distance measure used for clustering consists out of 8 conventional farmers, all of which but one are not selling meat directly to consumers (CDD2, CND2, CND3, CND4, CND6, CND10, CND11, CNS2). Cluster 4′s group map is the most distinct from the other group maps, as it core revolves around 5 concepts rather unfrequently included in other maps, namely "Animal Diseases, Plagues & Deaths", "Animal Handling & Welfare", "Hygiene and Food Security", and most prominently "Technical Results" and "Total Yearly Animal Production". The concept "Income" is the most central, as it is in other group maps. Concepts related to soil and plant production management, are mostly absent, and so are concepts related to external social relations or personal well-being concepts, namely "Satisfaction" and "Work Pressure". Instead, we find a strong focus on animal production-related concepts and farm economic concepts, and also the inclusion of feedback mechanisms from income back to production through investments. More than half of the farmers in this cluster referred to the following eight functional processes: "Get subsidies", "Commercial advantage through qualities of the product", "Increase scale animal production", "Invest in stable infrastructure and technical innovation", "Isolate from and eradicate pests and treat diseases", "Improve technical results", "Improve/maintain income", "Use knowledge of financial and technical results".
- Cluster 3 is a more heterogeneous grouping in terms of the activities these farmers engage in with three direct selling farmers (CDS2, CDS3, ODD7) and five not direct selling conventional farmers (CND7, CND8, CND9, CND12, CNS3). In the group map the concepts "Meat Quality", "Satisfaction", "Roughage Quality" come to the fore. The core of this group map is a number of returning relations connecting concepts like a spine. It starts from the "Use of Manure and goes to "Soil Organic Matter", to "Roughage Quality", directly to "Meat Quality" or indirectly via "Animal Resilience", and goes further either via "Direct Sale" or "Pricing, or directly to "Income, to end either in "Satisfaction, "Investment" or in reducing "Debts". "Cash crops" and "Subsidies" have also a relatively high percentage of inclusion. Qualitative analysis of these maps presents a similar story, with at

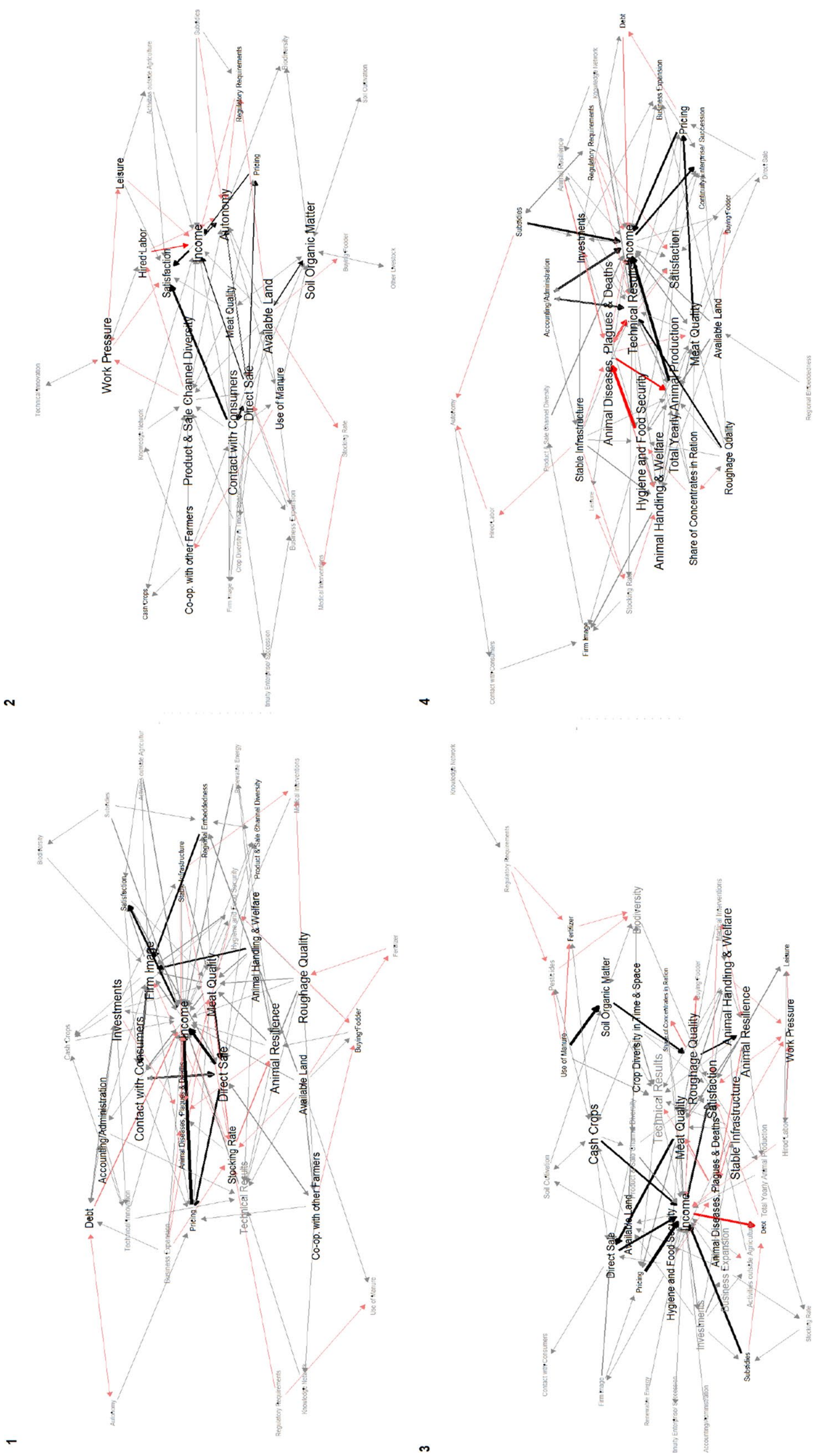

Fig. 4 Visualizations of cluster maps created by aggregating the maps. Relations and concepts in black and red are mentioned by more than 3 out of 10 farmers in the group. Thickness of relations and node label size correspond with strength of relations and centrality of concepts respectively. (For interpretation of the references to color in this figure description, the reader is referred to the web version of this article.)

least half the farmers referring to the following nine functional processes: “Crop production for sale”, “Integrated soil management”, “Reduce debts/maintain financial autonomy”, “Other things bring satisfaction”, “Balance workload”, “Get subsidies”, “Re-Use Biomass”, “Commercial advantage through qualities of the product”, and “Improve/maintain income”.

- Cluster 2 consists out of five direct selling organic farmers, in four cases with diverse agricultural activities (ODD2, ODD4, ODD5, ODD6, ODS1). The group CM is the most balanced of all clusters, with multiple concepts having a centrality score on average almost equal as “Income” has in this map, namely “Direct Sale”, “Contact with Consumers”, “Product & sale channel diversity”, and “Autonomy”. Other concepts of importance are “Satisfaction”, “Soil Organic Matter”, “Available Land”, and “Work Pressure”. Notably absent in these maps are concepts related to animal production and animal health, as well as concepts related to internal economic decision making such as “Accounting & Administration”, “Debts” and “Investments”. The relation “Contact with Consumers → Satisfaction” is characteristic for this cluster. At least three out of these five farmers refer in their map to ten functional processes. These include “Regulations hamper progress/vision”, “Set up alternative channels on your own”, “Prod. diversification for technical or commercial advantages”, “Income gives satisfaction”, “Integrated soil management”, “Balance workload”, “Re-Use Biomass”, “Improve/maintain income”, “Other things bring satisfaction”, “Set up/improve direct sale activities on your own”.
- Cluster 1, is a rather heterogeneous grouping of nine farmers in terms of a priori set types (CDD1, CDD3, CDS1, CND1, CND5, CNS1, ODD1, ODD3, OND1). The most central concept in the cluster map is “Income”, then “Direct Sale”, “Meat Quality” and “Firm Image”. The core of this map consists out of these four elements standing in relation with each other, with many other elements, less consistently integrated in the maps. Compared to cluster 2, these maps have a lower centrality score on average of “Satisfaction and Contact with Consumers” in favor for “Firm Image” and “Income”. At least half of the farmers drew relations to refer to the following four functional processes: “Commercial advantage through qualities of the firm”, “Set up/improve direct sale activities on your own”, “Commercial advantage through qualities of the product” and “Improve/maintain income”.

The clustering algorithm brought forth four groupings with some homogeneity in terms of included relations but also in terms of functional processes expressed through these shared relations. We now turn to interpret these groupings in the light of the comments farmers made before, during and just after the mapping exercise.

We find that a sizeable grouping of farmers (cluster 4) presented their farm in a rather distinct way. These conventional mostly whole selling beef farmers drew maps that revolved around the optimization of animal production, As one farmer in this cluster remarked: “*Everything depends on your* [technical] *results* […] *Now, we have a calving interval of about 370. In Belgium it’s 405–408 on average, and we don’t even follow this up too well, so we can still go lower*.” (CND11). This optimization of animal production envelops a number of interrelated processes related to intensively managing the feed and health of the animals, accompanied with on-going monitoring and investment in technical and economic progress of the farm. Farmers clearly sought to represent this complexity with the concepts and relations they included in their maps: *“So, your technical results need to be good, and then it’s about creating added value of your product. Of course, it can’t come at the cost of other things. So now we have primarily focused on getting good technical results, good animals, our own forage, airy stables, labor-efficient stables, so we can tend to many animals, high-quality animals, on our own, my wife and I”* (CDD2). The improvement of technical and economic results is also communicated to go together with making substantial investments in both land and infrastructure to cut costs through scale efficiencies. One farmer for instance remarked that he intended to “*… double in numbers* [of livestock]*, as these days, when they come get your animals with a truck and a driver, it makes a big difference whether they can take one, or they can take ten. And the cost price, you need to drop your cost price. So you need to be able to produce more cheaply*.” (CND4). Most of the mapping exercise was spent by these famers to communicating this synergy between animal production-related and internal economic decision making paying little attention to other aspects of farm functioning. Farmers also communicated the importance they attached to this complex, albeit reduced picture. “*It’s about what you get to keep at the end of the year, the rest is all tied to it. The welfare of the animals, the meat quality, the food safety, it’s all the same group, it all ties together, always. If you have less mortality, welfare is better, through hygiene you ‘ve got better welfare, if it’s better for your animals, you get better meat quality. It all hangs together!”* (CND6). Compared to other maps within the sample, there is little focus on influencing the terms of trade directly other than trying to meet the quality demands of the wholesale industry to get a good price.

We find a somewhat inverted situation for cluster 1, as what sets these maps apart from the other groups is their strong focus on external social relations. While for these farmers too, income generation is a central concern, the focus lies on the marketing of a product of a distinct quality tied to the reputation of the farm that attracts customers willing to pay a higher price for their product. In terms of managing internal physical resource flows, this cluster is, however, very heterogeneous. We in fact observe that these farmers handle very different definitions of meat quality, and hence the way it can be achieved in production. One farmer who sometimes promotes his product in the local supermarket, enumerated for instance similar quality characteristics valued by farmers in cluster 4: "[Our strong point] *is that through experience built up over the years, as well as because we can process our own concentrates and therefore know what we give to the animals,* […] *that we can market a remarkable cattle product, that meets all requirements, regarding [carcass] yield, health requirements, meat conversion, genetic origins* […] *that we can produce in an economic way"* (CNS1). Other farmers interpreted quality in a rather different manner: "*We don't force our animals. We never slaughter them when they are not ready,* […] *We let things develop at their natural pace, and that's also the cheapest way.*" (ODD3). From these two statements we can infer that farmers within this cluster may target quite different productivity levels. Nonetheless, they ended up in the same cluster, likely because the algorithm picked up on their shared articulation of the marketing aspects of their operation, compensating for the different or lacking articulation of the animal health and production management aspects. Furthermore, like farmers in cluster 4, farmers in cluster 1 pay on average little attention to functional processes integrating the farmer as a worker and manager in this whole. Consequently, this cluster envelops farmers, which presented farming, including their involvement alternative food networks as an economic activity first rather than as a way of life.

By contrast, the five farmers in cluster 2 communicated their involvement in alternative market channels not merely as a business opportunity, but also as a pursuit of autonomy, social contact, and/or personal satisfaction. One of these farmers put this also into words: "*Contact with consumer, that goes directly to this here, to satisfaction. Those Saturdays, they really are high days for me. That is when you get an answer on whether you have a good product, or not so much* […] *but also, just for that social contact, you know. If you have a small farm, and work alone, it really are pretty lonely days…"* (ODD5) Because of the inclusion of these other goals, the concern for a good income presents itself as only one of the considerations alongside the attention to soil and crop management, and personal satisfaction and well-being. While some concepts related animal production, the group map of these mostly diversified farmers shows that the optimization of animal production is less of a concern for these farmers than in other clusters. A key factor foregrounded by these farmers were labor and leisure time. There are different reasons, however, for these farmers behind including this aspect in their map. On the one hand, farmers may refer to the constant time-constraints they face when operating a diversified farm without (generally speaking) labor-saving technologies such as fertilizers and pesticides, while also needing to allocate time for processing and marketing activities. One farmer elaborated on this continuous balancing act represented in the connectivity he was drawing as follows: *"If you have diversity in sale channels, you can decrease your work pressure, because if you just depend on whole sale trading, it happens that they call at half 2 p. m,, and say, "it needs to be all there at dawn." Help! But in the summer months there is no* [help]. *By contrast, if I work with stores, I know in advance what they will order.* […] *So, if you have diversity here then you'll have less* [work pressure], […] *more work pressure means you need to involve more hired labor, and that has obviously a negative effect on your income.* […] *that hired labor, if you need that, that weakens your autonomy, because you need to find those people, find good ones, and that's a lot of stress."* (ODD5) On the other hand, one farmer in the cluster noted a sudden shortage of labor was in fact a driver behind him switching to organic farming and direct selling rather than expanding production the conventional way.: "*If you want to earn something in beef production, you either have to be enormously big, or you have do it differently, start direct selling, and being able to set yourself apart* […] *free time has been and is a bottleneck for me. Ten years ago, I thought totally differently, I was going for more volume, but my wife got sick,* […] *she was three years incapacitated, and then she's been able to think a lot, and then she has told me, "I don't want to work exclusively on the farm"* […], *but that made it so that I had to take over a lot of her tasks, and then you're confronted with your own limitations."* (ODS1). Land availability also shows up as a constraint on production in the cluster map, yet the lack of concepts such as "Debts", "Investments" and "Accounting/Administration" suggests these farmers are less intent to borrow for land: *"Debt is very important, but not here,* […] *if you have debts, you can't be autonomous."* (ODD5).

The final grouping, cluster 3, is of mixed nature in terms of activities of these farmers, but also in terms of functional processes. That this cluster is somewhat lacking in homogeneity is confirmed by the rather contradictory statements from farmers when asked about what were the most important aspects in their map. One farmer responded, "*Hygiene, cleanliness, quality and that you get your money's worth for what you do*" (CNS2). We heard a somewhat different story from a farmer in the same cluster who said that they were mainly concerned with animal welfare and "*keeping everything as natural as possible, without spraying products and so on, keeping the soil in order to produce good fodders, and keeping costs as low as possible.*" (CDS3). While there is a common concern about debts, though the group of farmers is mixed for their reason for including this concept. To most farmers in the cluster debts were significant, because they were looking to pay already incurred debts off, however, there was also a farmer who clearly were looking to make more investments. *"Look, if you have more income, then you'll invest more, then you'll have a better stable infrastructure, and a better stable infrastructure, gives you less work pressure, well less manual labor* […] *Business expansion that means more land, which increases your stocking rate,* […] *the more manure you use, the less fertilizers you require, the better your feed is, the less you need to buy, which brings it back to income"* (CND9). Still, on average, we find that compared to other clusters farmers in cluster 3 have less of a focus on income generation and investment, and more on personal well-being of the farm household. Furthermore, while their marketing strategies may differ, these farmers communicate that they also depend on other revenue streams such as cash cropping and subsidies. A number of farmers within this cluster indeed sought to represent how attention to the management of on-farm resources could lead to both good quality on-farm produced feed and meat quality, and hence a good income. One farmer put it as follows: *"In fact, the soil needs to be good, and your available land. Then you'll have good fodder to improve meat quality. If that's good, then that* [direct sale]*'s good. And then you have to make sure the animal's robustness is good, so that the meat quality is good.* […] *and the meat quality needs to be good for direct sale. And if you have direct sale, then you have contact with the consumer, right?* […] *And if this all good, that direct sale, how should you I put this, then your income is going to be good too, right? And if your income's good, you can do business expansion, which is why we do it in part. And if we have good income, we can invest, right? Yes, it all hangs together with this."* (CDS3).

Discussion

Like previous researchers (Fairweather and Hunt 2011; Akimowicz et al. 2016), we showed that it is possible to obtain CMs from farmers with a structured direct elicitation procedure with a free-hand technique. The quality of the maps obtained from these farmers varied markedly, as we experienced that for some farmers causal mapping was a challenging exercise, whereas for others, it appeared to be just a matter of translating onto a map a personal or acquired vision without challenging it. Based on the comments by farmers it is evident that the elicited causal maps are neither complete nor accurate representations of farmers' actual beliefs on the functioning of their farm. At some point, farmers could be so overwhelmed by the web of relations they were drawing, that it discouraged them from adding more concepts and relations. Many farmers said they could include many more concepts, but that it would become a tedious affair to do so or that it was better to stick with concepts that reflected most strongly their vision of farming. So rather than looking to recall all the relations they believe to operate at their farm, farmers are intentionally omitting certain concepts, to give a certain account of their farm. As observed by Jones et al. (2014), there is a difficulty representing a complex and dynamic phenomenon, such as farm functioning, on a two-dimensional, static visual-based medium.

Still, when it comes to eliciting comparable CMs for analytical purposes, we can speak of a relative success, and this is in no small part due to the methods chosen and developed. First, we believe that the choice for a structured, rather than a semi-structured approach, played a major role in our success. Fairweather & Hunt (2011) observed that farmers had difficulties to cite the most important factors themselves. Given that some respondents had already difficulties with weighing the importance of given concepts, asking them to come up with the concepts themselves would likely have overburdened them. Second, we believe that careful construction and testing was a key to develop a concept pool that proved to be sufficiently diverse and wide in scope so that all farmers found concepts that resonated with their vision of their farm, without being overwhelmingly large. A third success factor was the choice for the free-hand technique, as this technique gives immediate overview of their presentation of their farm up to that point. Several farmers even said they had enjoyed and learned something from the exercise. A less interactive technique, such as the pairwise comparison technique with a questionnaire would presumably have made it harder to keep farmers engaged. Lastly, we note that the quality of maps in terms of detail and consistency improved throughout the gathering of the data, as the required interviewer skills for direct elicitation, such as teaching the rules of the mapping process, encouraging and making the farmers comfortable, were gained through experience with the method. We therefore highly recommend including sufficient pilot interviews.

When audiotaping the mapping process, we noticed discrepancies between what farmers orally stated and the relationships they drew. This was an obstacle to characterize these farmers' beliefs and the functioning of their farms. We decided therefore to overlay the relations drawn by farmers with our own judgments about what farmers may have intended to draw, based on their oral report. This is not unheard of in the CMing research community at all, as this precisely agrees with how one would obtain CMs with any indirect elicitation method. Moreover, it is consistent with our understanding of these models as hermeneutical enablers, not only to farmers, but also to researchers. The processing step allowed us to more fully absorb the information farmers were providing us into matrices, which were instrumental in turn to (i) visualize individual maps and group maps, (ii) discern aggregate patterns and (iii) compare the content of these maps in an automated manner. However, our analysis of comments made by farmers, revealed that this stylization presses subtle but important differences in meanings attributed to the connections out of the analysis, which we compensated by identifying functional processes in these maps. Just as other CMing studies with farmers (Christen et al. 2015; Micha et al. 2019), we found that income generation is of great importance to farmers. Yet, the CMs also show that the income generation process is but a part, though a crucial one, of a tight connectivity of production and marketing activities that generate not only income but also satisfaction, feeding back into further investment to improve production conditions in a variety of ways or improve marketing arrangements directly. So while income generation clearly is recognized by farmers as a necessary condition to continue farming, this reality can be perceived and acted upon differently by farmers and their CMs and comments reflect that. Table 18 and 19 indeed show farmers prioritize different functional processes in unique ways, highlighting that farmers in this context may socially construct multiple contrasting optima (van der Ploeg 2010). All of this suggests that content analysis needs to go beyond the nodes and edges included in the maps, but should extensively rely on qualitative information gathered alongside the physical maps to check the quality of the information going into quantitative analyses and to further interpret the results these may yield.

While multivariate methods are rather blunt tools to classify, our application of a clustering method confirmed that this sample could be split up into smaller groups farmers representing their farm in a somewhat typical manner. One cluster of mostly conventional whole selling farmers focused on the control of diseases and improving economic efficiency of animal production to optimize income generation. They may very well represent a section of beef farmers which have accepted to work within an intensive "Belgian Blue" system for beef production and commercialization in Belgium (Stassart and Jamar 2008), with the further indication that farmers are part of the reproduction and expansion of this system by continuously reinvest in optimizing and expanding these systems. Farmers in a second cluster emphasize personal satisfaction, as well as the improvement of meat quality through optimal roughage production and soil management. A third cluster, consisting exclusively of organic direct selling farmers, sought to improve autonomy and satisfaction by establishing good relations with consumers. The last cluster of farmers, focuses marketing aspects to improve income, but were mixed in terms of actual production strategies. Clustering thus proved useful to trace some of the broader patterns within the data, such as the existence of farmers who appear to be more business-minded versus those foregrounding their quality of life, farmers who are more focused on production and other more on marketing-minded, farmers who are more investment-minded, and others who look to get by with little inputs and capital investment. The identification of distinct clusters conforms with other recent empirical findings (Beingessner and Fletcher 2020), suggesting that farmers may position themselves differently towards the dominant agri-food system, with some farmers resigned to or even promoting going standards of production and consumption, others withdrawing from intensive production and actively constructing alternative channels around other, potentially contradictory notions of quality.

The clustering thus highlighted that this diverse group of farmers may represent their farm differently, but also that there is no one-to-one relationship between the activities of farmers and how they would draw a CM to represent their farm. This of course has ontological reasons (farmers may have different priorities despite their similarity in activities), but also methodological reasons, namely the lacking capacity of the method to register actual differences in viewpoints. The distance measure used for clustering doesn't consider the content differences in terms of meaning attributed to concepts and relations (Markóczy and Goldberg 1995), which our qualitative clearly showed to be present. This hampers accurate content comparison. Moreover, given the many omission errors bound up with the chosen data gathering method, no systematic account of farmers' beliefs is produced. With little shared drawn relations between individual maps, the data on which the clustering happens can be rather circumstantial. The information on which this classification is based has its limitations, and therefore the classification itself, as further study of the comments made by farmers confirmed. While other publications have touted CMing as an effective method for comparative analysis of actors' perspectives (*e. g.* Mathevet et al. 2011; Bosma et al. 2017), based on our findings, we believe that other methodologies, like Q-methodology, would have been more efficient and effective to classify cases based on farmers' perspectives. The key advantage CMing has, however, over other data gathering methods is that it produces systems representations, rather than sets of discrete beliefs about different aspects of farming. Individual maps show that even with little concepts and relations, farmers are enticed to represent their farm as a connected whole that involves multiple aspects. Farmers were therefore able to communicate to us how these beliefs are linked together, instead of leaving this job entirely to the analyst. As such we would say that our approach was effective in exploring farm functioning in its complexity, that is how different aspects of farming may be put together by farmers, and less effective in exploring farm functioning in its diversity, that is in what way particular complex systems are different.

Conclusion

CMs are best interpreted as communication tools for the respondent farmers to construct an image of their farm, rather than complete or accurate representations of their beliefs. CMs may disclose what aspects farmers are working on, and what they are working towards, and help theorize how these aspects fit together as a whole. They therefore help us to consider the material impact of farmers' views being constitutive of farm functioning, as they translate into actions that reconfigure the farm and its environment, giving the farm as a whole dynamism and purpose. While the applied CMing method showed a limited capability of classifying farmers based on their beliefs about farming, it did provide systemic representations constructed by farmers on varying /the range of connection between different aspects of farming. Considering these findings, we believe CMing, may inform further interdisciplinary and holistic analyses of farmers' decision making and of the actual functioning of these systems.

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Louis Tessier is a Junior Researcher at the Social Sciences Unit of the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO). After obtaining the degree of M.Sc. in Bioscience Engineering (Ghent University), he works since November 2016 on a doctoral research project in agreement with the Catholique University of Louvain-la-Neuve (UCLouvain) which explores the relevance of agroecology as a body of thought to the Flemish beef sector. Currently concluding his doctoral research, he seeks to build out his research experience further by developing and applying critical, interdisciplinary methodologies and conceptual lenses to analyze and support food system transitions.

Jo Bijttebier is a Senior Researcher at the Social Sciences Unit of ILVO. She holds an M.Sc. in Bioscience Engineering (Catholic University of Louvain) and a Ph.D. in Veterinary Sciences (Ghent University). She builds her expertise on learning processes with stakeholders striving for sustainable agriculture, including topics as knowledge exchange, co-creation of innovation and systems thinking.

Fleur Marchand is Scientific Director at the Social Science Unit of ILVO and Lecturer at the University of Antwerp. She is doctor in science (University of Antwerp, 2006) and M.Sc. in Bioscience Engineering (Ghent University, 2001). She builds her expertise mainly on empirical case-studies with stakeholders striving for sustainable agriculture and food chains. She uses mainly a transdisciplinary and system approach focusing on the following research topics: knowledge exchange, agroecology and transition of the food system. On these topics, she supervises Ph.D. students and coordinates different national and international projects.

Philippe V. Baret is Professor of System Analysis, Genetics and Agroecology at the Faculty of Bioscience Engineering at the UCLouvain. As Director of the Research Team Sytra, he coordinates research on the transitions of agricultural and food system based on participatory prospective approaches. He is convinced that a systemic identification of lock-ins and an inclusive approach of the diversity of present systems are key elements for new trajectories of food systems.