FOODLEVERS

Milestone 3.1: Guidelines to carry out the FCM survey

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Stakeholder decision making model (Task 3.1)

This task will map actors' knowledge and perceptions in a Fuzzy Cognitive Mapping (FCM). The FCM develops a behavioral model of the system exploiting the experience and knowledge of stakeholders. FCM will be used as a decision-making tool to help individuals and communities to understand the impacts associated with environmental, social, governance and economic changes and to develop adequate policy actions and mitigation/adaptation strategies.

Fuzzy logic Cognitive Map model building is a multi-step process that captures causal knowledge in the form of cognitive maps, formally describes these maps as adjacency matrices, and applies neural network computation to refine the model and analyse model results.

The FCM analysis will focus on three goals:

1) define the important components relevant to a community;
2) define the strength of relationships between these components and
3) run "what if" scenarios to determine how components might react under a given scenario (range of possible conditions).

Background

The sustainability of food and farming systems continues to be one of the most complex and critical challenges for scientists, policy makers, private sector stakeholders and civil society alike (Borsellino, 2020). While steady progress has been made in the development of goals, frameworks, instruments and literature, that all provide various assessment methods and indicators, there remains an urgent need to identify and evaluate the factors that encourage and discourage sustainable food systems in order to inform more efficient policy design and support mechanisms for optimal climate change mitigation (Necpalova et al, 2018).

The FOODLEVERS project is grounded on the premise that attaining sustainable food production and consumption will require transition from the current linear food systems, to more circular systems that also re-connect producers and consumers. Such sustainability transitions are complex processes. In addition, many sustainability interventions focus on "highly tangible, but essentially weak, leverage points" (Abson et al, 2017), thus they do not address key problems.

Based on the framework of leverage points for sustainability interventions (Meadows, 1999), Abson et al. (2017) propose a research agenda based on three realms of "deep leverage" to address in sustainability transitions, such as those required to transition towards resource-efficient, circular and zero-waste food systems:

- **"re-connect"** people to nature to encourage sustainable behaviors
- **"re-structure"** institutions and consider how institutional dynamics can create an enabling environment for sustainability
- **"re-think"** how knowledge is created and used, shared and validated

Research that addresses the relationships between the above areas can build an understanding of effective practices and how these interact with the design of and intent behind food systems

(Fischer and Riechers, 2019). Therefore, these three realms of deep leverage build the theoretical approach of the FOODLEVERS project.

Problem statement

Despite the recent uptake of innovative production systems, food systems continue to move on unsustainable trajectories (Béné, 2022). This can be explained by many sustainability interventions addressing solely more obvious but less powerful areas of intervention rather than engaging with the root causes of unsustainability. Instead, FOODLEVERS focuses on identifying those leverage points at which interventions promise far more potential to further develop and scale-up existing innovative organic and sustainable Food Systems (FSs).

Aim and specific objectives

The project aims to elicit the often unspoken knowledge and perceptions of 'in-field' experts including farmers, policy makers, researchers and consultants in the 7 countries of the FOODLEVERS consortium.

The first objective is to develop a Fuzzy Cognitive Map using Mental Modeler software which is a semi quantitative modeling tool. The tool will define:

a. the important components of the system and
b. the relationship between those components
c. the degree of influence that one component can have on another

Once models are built, increasing or decreasing the components included in the model different scenarios of change will be examined.

Methodology

A Fuzzy-logic Cognitive Map can be developed via face-to-face or online workshops, where a group of stakeholders meet in one place at the same time or via organizing asynchronous participation (Pahl-Wostl, 2008). In the asynchronous option, inputs from different stakeholders are collected at different times and locations. However, asynchronous method will require more post-processing work by the facilitator while face to face/online workshops can enable respondents to take up and integrate contrasting views which can provide a more coherent and complete picture of the knowledge domain than a series of individual interviews because respondents can build on each other's knowledge.
For this study was decided to organize face-to-face/online workshops.

The FCM modeling will be carried out in several steps, in November and December 2022 and will be conducted by stimulating both individual and shared brainstorming on the topic. The discussion has to be focused on the 4 thematic fields identified in the framework laid out in the United Nations Sustainability Assessment of Food and Agricultural Systems (SAFA), (United Nations, 2013): *environment*, *economy*, *social*, *governance*. The logic maps focused on these thematic fields will be implemented on both stakeholder category level and grouped level. Facilitators may guide all the steps of the workshop supporting the participants to draw the maps. They have to try as

much as possible not influencing the perception of the participants concerning the identification of the variables that affect the organic and sustainable food systems and their relationships.

Facilitators has to consider the main research questions of the FOODLEVERS project:

1) *what are the most important factors relevant to both sustainable and unsustainable development in organic and agroecological food systems?*
2) *what is the strength of the relationships between these factors and*
3) *how do these factors react under different scenarios?*

Face-to-face or online group workshops setting

The aim of the FCM methodology is to represent casual relationships as perceived by stakeholders. This require an elicitation process and a workshop will be organized involving different categories of stakeholders. Moderated group discussions in which respondents take up and integrate contrasting views can provide a more coherent and complete picture of the knowledge domain than a series of individual interviews because respondents can build on each other's knowledge.

***Step 1*: definition of the objectives and stakeholder selection.**

Modelers should inquire about problems, desired situations that should remain the same, undesired states that need to change, and the decision alternatives available in the given situation. The main objective of FCM is to identify critical intervention points and leverage opportunities to promote the transition towards resilient organic food systems. The central issue to be discussed is "what are the key leverage points to establish organic/sustainable food systems more efficient and sustainable?"

As such, organic and sustainable food system is the central concept of FCM. The aim of the workshop is to elicit the components (concepts) of the organic and sustainable food system and their positive/negative relationships.

FCM will target four categories of stakeholders that represent key actors of the organic food system:

- ✓ farmers,
- ✓ policy makers,
- ✓ researchers,
- ✓ advisors.

Between 3 and 5 people for each category of stakeholders should be involved in the study.

***Step 2*: facilitation of moderated group discussion.**

At the beginning of the workshop the moderator has to give a general overview of the organic food production in his country taking into account the SAFA framework: *environment*, *economy*, *social*, *governance*. It has to be just an introduction that facilitate a group discussion in which respondents take up and integrate contrasting views.

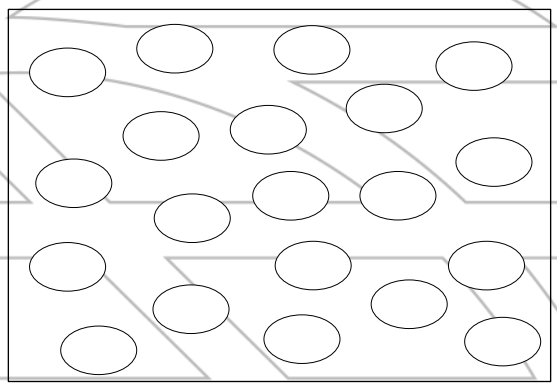
After that, respondents have to briefly trained in:

- cognitive mapping,
- identify concepts that pertain to the knowledge domain,
- document their causal knowledge in ''loop and arrow'' diagrams.

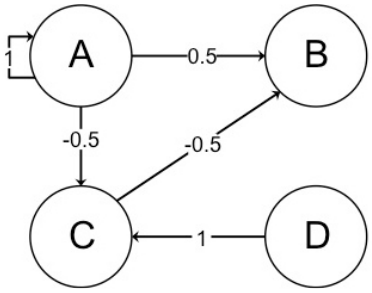
Stakeholders should be asked to consider as wide a range as possible of concepts/factors/drivers including governance, social, economic, and environmental factors influencing organic/sustainable food production, but they **should not be given a predefined list of concepts.**

Step 3: create cognitive maps in a group setting.
Stakeholders interact with the FCM modeler and each other using a workshop setting in which the respondents communicate their ideas and draw a cognitive map for each stakeholder category. In this step, a list of concepts that stakeholders mentioned should be collected and analysed clustering similar concepts/terms together.

Stakeholders will construct their map on a simple sheet of paper on which circles must have been previously drawn. Stakeholders should be given a black pen to write down concepts, a blue pen to draw positive relationships and a red pen to draw negative relationships.



Step 4: capture the causal connections and their weight in sequence steps to avoid high cognitive demanding. Once the connections have been identified the stakeholders have to weight it. Stakeholders are invited to assign a weight to all the connections. The question to ask stakeholders shall be "*how much does the concept A impact on the concept B*?" (Wei et al., 2008; Carvalho, 2013). Stakeholders can assign a quantitate value between -1 and +1. These direction of the arrows, positive or negative sign and numbers (between +1.0 and - 1.0) all indicate the degree of influence one component can have on another.



Step 5: after the stage of knowledge elicitation and the process of developing individual maps, the proceeding of post-processing maps and aggregation has to be implemented. This is a time-consuming activity and requires the involvement of stakeholders to check inconsistencies in their maps and avoid pitfalls (Jetter & Kok 2014).
Mental Modeler can be used to draw the maps in a digital format, directly online by registering at www.mentalmodeler.com and the factors can be grouped in the four SAFA thematic categories.

Each original map, as drafted by the stakeholder category is automatically converted into a composite matrix when is drafted in the Mental Modeler software.
At this point, the total cognitive map has to be drafted by aggregating the stakeholder category maps to examine the function of the entire community map. Mental Modeler allows to build Fuzzy-logic Cognitive Maps easily and intuitively. It is a mathematical integration of cognitive maps that requires some upfront work for the standardization and integration of the concepts but the results will be used to draw conclusions about the differences between stakeholder knowledge systems and to compare the benefits and limitations of integrating knowledge systems. The post-processing normally entails deleting relationships, adding relationships, merging similar concepts and renaming ambiguous ones with the involvement of stakeholders to reflect the respondents' knowledge of the system and its behavior. Stakeholders are involved because clarifications are normally needed. It is important to verify if there are contradicting relations, i.e. the same relation opposite signed by different stakeholders, or inconsistencies, and resolve them.

The workshop can be organized into 3 sections:

1. introduction and overview of organic production systems (max 1 hour);
2. map construction by stakeholder categories (on average about 1 hour);
3. construction of the total map (the time required).

The collection of maps should take between 45 and 180 minutes, on average about 1 hour for the construction of the groups map documenting causal knowledge in ''loop and arrow'' diagrams and giving a weight to them.

Scenario building

Once model is built, the workshop is over and by increasing or decreasing the components included in the model allows to examine different scenarios of change.

To develop the scenario analysis is important to take into account the structural measurement of the components considering the following:

- **Indegree**: ingoing connections
- **Outdegree**: outgoing connections
- **Transmitter**: components which only have "forcing" functions; indicates number of components that effect other system components but are not affected by others (Eden et al. 1992) - *positive outdegree but no indegree => Drivers or forcing functions*
- **Receiver**: components which have only receiving functions; indicates the number of components that are affected by other system components but have no effect (Eden et al. 1992) - *indegree but zero outdegree*
- **Ordinary**: components with both transmitting and receiving functions; indicates the number of concepts that influence and are influenced by other concepts (Eden et al. 1992)
- **Centrality**: absolute value of either (a) overall influence in the model (all + and – relationships indicated, for entire model) or (b) influence of individual concepts as indicated by positive (+) or negative (-) values placed on connections between

components; indicates (a) the total influence (positive and negative) to be in the system or (b) the conceptual weight/importance of individual concepts (Kosko 1986a). The higher the value, the greater is the importance of all concepts or the individual weight of a concept in the overall model

- **C/N**: number of connections divided by number of variables (concepts). The lower the C/N score, the higher the degree of connectedness in a system (Ozesmi and Ozesmi 2004)
- **Complexity**: Ratio of receiver variables to transmitter variables. Indicates the degree of resolution and is a measure of the degree to which outcomes of driving forces are considered. Higher complexity indicates more complex systems thinking (Eden et al. 1992; Ozesmi and Ozesmi 2004)
- **Density**: number of connections compared to number of all possible connections. The higher the density, the more potential management polices exist (Ozesmi and Ozesmi 2004; Hage and Harary 1983)
- **Hierarchy Index**: Index developed to indicate hierarchical to democratic view of the system. On a scale of 0-1, indicates the degree of top-down down (score 1) or democratic perception (score =) of the mental model (McDonald 1983)

Components in the FCM can be increased or decreased to understand how the system would react under a range of policy, social, economic or environmental changes (Kosko 1986).

Expected results

The project will generate novel data that will be of great benefit to a number of stakeholder groups, including:
(i) farming businesses currently using unsustainable farming methods. Evidence will be provided to this group via established networks and through the popular farming press, national farmer groups in order to effect improvements in sustainability for large numbers of farmers, food processors and distributors in many jurisdictions.

(ii) policy makers, on the components underpinning better/worse social, environmental and economic performance within innovative farming systems through policy briefs to be distributed to officials in FOODLEVER country ministries of agriculture.

(iii) relevant academics and grant-holder networks such as the Global Food Security programme and researcher networks (e.g. Food Climate Research Network) to inform the development of methods for assessing the impact of utilising key leverage points in innovative farming systems. Research outputs will be shared through dissemination via academic journals and the FOODLEVERS webpage.

References

Abson, D.J., *et al. (2017):* Leverage points for sustainability transformation. *Ambio 46, 30–39*. https://doi.org/10.1007/s13280-016-0800-y

Alizadeh, Y., Jetter, A., 2017, July. Content analysis using fuzzy cognitive map (FCM): a guide to capturing causal relationships from secondary sources of data. In: 2017 Portland International Conference on Management of Engineering and Technology (PICMET). IEEE, pp. 1–11.

Béné, C. (2022) 'Why the Great Food Transformation may not happen – A deep-dive into our food systems' political economy, controversies and politics of evidence'. *World Development, Volume 154, 105881*. https://doi.org/10.1016/j.worlddev.2022.105881.

Borsellino, V., Schimmenti, E. and El Bilali, H. (2020) Agri-Food Markets towards Sustainable Patterns. *Sustainability 2020, 12, 2193*. https://doi.org/10.3390/su12062193

Carvalho, J.P., 2013. On the semantics and the use of fuzzy cognitive maps and dynamic cognitive maps in social sciences. Fuzzy Sets Syst. 214, 6–19.

Diniz, F.H., Kok, K., Hoogstra-Klein, M.A., Arts, B., 2015. Mapping future changes inlivelihood security and environmental sustainability based on perceptions of small farmers in the Brazilian Amazon. Ecol. Soc. 20 (2).

Fischer, J. and Riechers, M. (2019) 'A Leverage points perspective on sustainability'. *People Nat. 1: 115– 120*. https://doi.org/10.1002/pan3.13

Glory I. Edwards & Kasper Kok, 2021. Building a Fuzzy Cognitive Map from stakeholder knowledge: An Episodic, asynchronous approach. Current Research in Environmental Sustainability 3 (2021) https://doi.org/10.1016/j.crsust.2021.100053

Gray, S. A. et al, (2013) 'Mental Modeler: A Fuzzy-Logic Cognitive Mapping Modeling Tool for Adaptive Environmental Management'. 46th Hawaii International Conference on System Sciences, 2013, pp. 965-973. https://www.semanticscholar.org/paper/Mental-Modeler%3A-A-Fuzzy-Logic-Cognitive-Mapping-for-Gray-Gray/a0b807d7a77506be96df3349b236c0eea3c894d8

Gray, S.A., Gray, S., De Kok, J.L., Helfgott, A.E., O'Dwyer, B., Jordan, R., Nyaki, A., 2015. Using fuzzy cognitive mapping as a participatory approach to analyze change, preferred states, and perceived resilience of social-ecological systems. Ecol. Soc. 20(2).

Gray, S., Voinov, A., Paolisso, M., Jordan, R., BenDor, T., Bommel, P., Glynn, P., Hedelin, B., Hubacek, K., Introne, J., Kolagani, N., 2018. Purpose, processes, partnerships, and products: four Ps to advance participatory socio-environmental modeling. Ecol. Appl. 28 (1), 46–61.

Hobbs, B.F., Ludsin, S.A., Knight, R.L., Ryan, P.A., Biberhofer, J., Ciborowski, J.J., 2002. Fuzzy cognitive mapping as a tool to define management objectives for complex ecosystems. Ecol. Appl. 12 (5), 1548–1565.

IPCC, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Meadows, D., (1999) Leverage points. Places to Intervene in a System, *19*. http://drbalcom.pbworks.com/w/file/fetch/35173014/Leverage_Points.pdf

Mitter, H. et al. (2020) Shared Socio-economic Pathways for European agriculture and food systems: The Eur-Agri-SSPs. *Global Environmental Change, November 2020, 102159*. *https://doi.org/10.1016/j.gloenvcha.2020.102159*

Necpalova, M., *et al.* (2018) Six Potentials to mitigate greenhouse gas emissions from Swiss agriculture. *Agriculture, Ecosystems & Environment, 265, 84-102*. https://doi.org/10.1016/j.agee.2018.05.013.

Ozesmi, U., Ozesmi, S.L., 2004. Ecological models based on people's knowledge: a multistep fuzzy cognitive mapping approach. Ecol. Model. 176 (1–2), 43–64.

Pahl-Wostl, C., 2008. Chapter five participation in building environmental scenarios. Dev. Integr. Environ. Assess. 2, 105–122.

Voinov, A., Kolagani, N., McCall, M.K., Glynn, P.D., Kragt, M.E., Ostermann, F.O., Pierce, S.A., Ramu, P., 2016. Modelling with stakeholders–next generation. Environ. Model. Softw. 77, 196–220.

United Nations, (2013) 'Sustainability Assessment of Food and Agriculture systems'. Available at: https://www.fao.org/nr/sustainability/sustainability-assessments-safa/en/ (Accessed on 23rd of September 2022)

Wei, Z., Lu, L., Yanchun, Z., 2008. Using fuzzy cognitive time maps for modeling and evaluating trust dynamics in the virt