Deliverable 1.3:
Data collection protocols

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1. Objectives

The overall objective of this deliverable is to detail the protocols to be followed to implement the tasks that require data collection. The Milestone 1.3 (Data needs catalogue) developed a schematic framework of the qualitative and quantitative data necessary to carry out different tasks within WP1, WP2 and WP3. This report aims to focus on the methodological approaches that each task needs to adopt and implement to collect data.

For each task, the following specific questions should be addressed:

- What are the main objectives of each task and how its implementation is related or linked with the others;
- Which research methods like meetings, focus groups, interviews, workshops, etc. are needed to implement each task;
- Which actors or stakeholders need to be involved and how many of them are necessary to validate the expected results

Based on the preliminary data collection plan that has been adopted in M1.3, in the following sections each task is described in terms of its specific logical schemes and methodological approaches.

2. Reference systems of the organic sector (task 1.2)

The aim of this task is to characterize and assess reference systems from the mainstream organic/sustainable sector. The main objective of this study is to define a mainstream organic food system. At a later stage in the project, this will serve as a counterpart to compare with the innovative food production systems analysed to highlight advantages and shortcomings of mainstream organic/sustainable systems. Food system is understood here as follows: "Food systems encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded" (FAO, 2018). Basically, the report includes three modules of mainstream organic system assessment:

1. overview of organic farming in European Union (EU) and FOODLEVERS' case study countries,
2. literature review on sustainability of organic systems;
3. evaluation of organic farms in EU.

The first two sections were prepared using country-specific benchmarking and literature data. Analysis within the third section was fed with FADN (Farm Accountancy Data Network) data, acquired from the European Commission (EC). Analysis of food systems at farm level is considered to be representative for the agricultural sector. At the moment, FADN is the only source of consistent data, that allows the comparison of farms between all the countries. However, FADN provides data mainly on economic aspects and lacks of information, relating to social and environmental performance of farms which makes any sustainability assessment impossible. In the Farm to Fork Strategy, the EC announced its intention to convert the FADN into FSDN (Farm Sustainability Data Network) in order to collect farm level data addressing social-environmental policy targets and other sustainability indicators. As the system assessing farms sustainability is expected in the future, the FOODLEVERS project assumptions requires comprehensive evaluation of food system sustainability based on thorough and transparent analysis using already available and update indicators. That will help to formulate conclusions, useful for further analysis, when

new data under new criteria will become available. For the purpose of a holistic assessment of organic food system in the EU, existing quantitative and qualitative information is explored to demonstrate the state of the art on organic farming performance in terms of the mainstream organic sector. The completed diagnosis of the sector provides a general reference model for the sustainability assessment of selected innovative organic case studies (WP2) and business-as-usual scenario for the development of alternative scenarios (WP3).
The report includes analyses of the situation of the organic farming sector in the EU in terms of farming characteristics, food production, sustainability and the farms features. Although the organic area, the number of producers and processors is increasing at EU level, the development of the organic sector varies greatly between the EU countries, as regards the general conditions, market competitiveness and policy support. Organic agriculture is subject to strict regulations and controls, imposed by certification bodies to keep allegedly a sustainability standard of agricultural production, however the holistic performance of organic farming against conventional systems continues to be debated. The environmental footprint of organic food systems depends on the functional unit of assessment (area vs. product). Reliable valuation of climate impact needs to include particularly organic inputs and agricultural materials. In order to be precise, it should also extend to ecosystem services. All that increases complexity and remains the challenge.
At the moment, the most useful dataset for sustainability assessment of organic mainstream farms remains the FADN. The reference system is corresponding here to the country and farm type, due to farm specific features. Despite FADN database includes only economic data it is considered the most representative source of data related to agricultural holdings in the Union. An important shortcoming of the FADN is the surveys cover only farms that have proper economic size. Moreover, the EC does not publish averaged results data from the set comprising fewer than 15 farms. The analysis found representativeness level of organic farms in the total country pool of FADN farms is much varied - from 0.5% for Poland and 0.9% for Finland to 16,7% for Italy. In terms of physical (area) size, organic farms are on average largest in United Kingdom (171 ha) and the smallest in Poland (15 ha) and in Italy (25 ha). Poland and Italy are the countries with the greatest labour inputs in organic farming. A clear difference can be observed between Poland/Romania and other countries in terms of total farm output (almost 4 times less in Poland than for Italy where organic farms are most profitable), however gross farm income proved to be the lowest in UK organic farms. Unfortunately, there was too little information on organic farms in Romania to obtain the data for further analysis, hence the country was excluded from further detailed analysis. Small number of horticultural organic farms did not allow to gather data at level of each of country studied as well. Only two countries could be assessed in terms of organic wine farms, organic farms with other permanent crops and organic farms with granivores production (for Germany and Italy; Italy and Poland; Germany and Italy, respectively). Farms keeping specialised livestock production are most numerous organic farms, hence we can consider them the most comparable organic farm types.

3. Ecosystem service assessment (Task 2.1)

This task aims to evaluate the ES provided by agricultural value chains in different farming systems across a range of areas using the PG Tool. The PG tool is a sustainability assessment tool which analyses farm performance, using environmental, economic and social indicators. The tool facilitates a dialogue between the assessor and the farmer and can be used to identify areas for improvement, possible solutions and monitor changes over time. The PG Tool needs to be adapted including indicators responding to the specific characteristics of the partner case studies. The identification and selection of these indicators is implemented through a literature search adopting a common protocol based on the following criteria:

- The literature search should be carried out in a **systematic and rigorous** manner (although there is insufficient time to carry out a full systematic review);
- Based on the main objective of FOODLEVERS, it must consider organic production systems, including the use of **woody components**, **residual wastes** and **co-products** for non-food purposes**.** This should be done from an ecosystem service perspective;
- It must consider ecosystem service (**provisioning, regulating and maintenance, and cultural services)** indicators (WP 2 description) drawing on the Common International Classification of Ecosystem Services (CICES);
- It should inform the identification and selection of indicators for human nutrition, social well-being and biodiversity for the Life Cycle Assessments in WP2;
- It should draw on both **academic** and **grey literature**, including **previous work by the consortium** and **general databases.**

To begin with, the key categories of organic production systems for consideration in the review are identified:

<u>Mainstream:</u> Conventional organic systems (reference systems from task 1.2)

*<u>Innovative:</u> **multifunctional** and **innovative organic** systems where food production is fully integrated as part of a holistic farm management approach.*

- Biodynamic mixed farming (DE, UK)
- Silvopastoral systems with walnut and olive grazed by hens (agroforestry)(IT)
- Grass-fed organic and silvopastoral systems (agroforestry)(PL)
- Permaculture (RO)
- Mushroom cultivation in forest farming (FI)
- Certification, production techniques, Community-Supported Agriculture (CSA)(BE)

The literature review should begin with a search of the literature on ecosystem service indicators associated with the identified organic production systems: biodynamic farming (DE & UK), agro-forestry (IT & PL), permaculture (RO), forest farming (FI), Community-Supported Agriculture (BE) etc. Ecosystem service indicators are a very large and complex topic, so for this project only a **<u>brief overview</u>** should be made, with a view to **<u>quickly identifying indicators</u>** that might be useful for ecosystem service assessment of the different production systems. A particular focus will also be given to the identification of indicators for human nutrition, social well-being and biodiversity, to inform the Life Cycle Assessment work for each case study.

A step-by-step approach is explained in more detail in appendix 1. Searches should be carried out (**<u>as time allows</u>**) using Google, Google Scholar, Web of Knowledge, Scopus, BIOSIS Previews, ScienceDirect, etc. They should also cover sources such as EEA, EuroStat, FADN, FAOSTAT, Hedgelink UK, OECD, UNECE and World Bank. They should cover grey literature as well as academic research papers and should also include websites, and it should be ensured that the final literature reviewed for each search term covers a variety of these sources. It may be necessary to alter this list according to similar national search engines, grey literature sources and academic databases. A suggested order of prioritisation to ensure that this is the case is: Google or whichever search engine is dominant in your country (returning grey and academic literature), Google Scholar or the best equivalent for your country (easy to access search for academic literature), EuroStat, and then the other grey literature sources (EEA, FADN, national sources etc.) in alphabetical order. Finally, other sources of academic literature can be returned to in the order listed (or adapted to national context).

In order to limit search results, inclusion only of literature post-dating the **1992 Rio Summit** is suggested. Filtration of the results by the researcher to include only those that relate to **organic** production systems.
Searches should be conducted and the relevant results (i.e. after filtration by the researcher) drawn from the **first 20 search results**. If a search yields a large number of relevant results, it is further recommended that a sensible cut-off of is applied – the **first five items** of relevant literature from any one search from any one search location, for example, with duplicates between search locations **deleted and not replaced**. A maximum of **15 items of literature** should initially be reviewed relating to any one search term. Should less than 50 sources be found to review following exhaustion of search terms and locations, the researcher can then return to the cut-off searches. However, the researcher should also apply some discretion: if, after 15 items have been reviewed, there is still little repetition in the indicators being identified, reviews should continue until few novel indicators are being found.
Searches should be conducted for each production system until search terms and the search locations listed above are exhausted, or until a maximum of **50 literature sources** have been reviewed. All search terms used and databases searched should be listed so that the method used is transparent and the search could be repeated by a third party. The total number of "hits" of each search and the number of literature items reviewed from it should also be recorded and specified in milestone 2.1 *PG tool adapted* report.
The following search terms (translated into the national language) are suggested. It is recommended that the order in which the search terms are used is chosen to ensure sources covering the entire scope of each production system are found for review:
* indicates inclusion of all endings of given search term. Google will do this automatically but other search engines may not. Note that different search engines may require a different symbol.

Biodynamic mixed farming (DE, UK)

"ecosystem service* indicator" "provisioning services" "regulation and maintenance" "cultural services" "human nutrition" "biodiversity" "social-wellbeing"	AND	Mixed farming biodynamic AND farming biodynamic AND "short supply chain" biodynamic AND "distribution channel"

Silvopastoral systems with walnut and olive grazed by hens (agroforestry)(IT)

"ecosystem service* indicator" "provisioning services" "regulation and maintenance" "cultural services" "human nutrition" "biodiversity" "social-wellbeing"	AND	agroforestry AND walnut agroforestry AND olive agroforestry AND hens silvopast*

Grass-fed organic and silvopastoral systems (agroforestry)(PL)

"ecosystem service* indicator" "provisioning services" "regulation and maintenance" "cultural services" "human nutrition" "biodiversity" "social-wellbeing"	AND	agroforestry AND "grass fed" agroforestry AND "short supply chain" agroforestry AND "distribution channel" silvopast*

Permaculture (RO)

"ecosystem service* indicator" "provisioning services" "regulation and maintenance" "cultural services" "human nutrition" "biodiversity" "social-wellbeing"	AND	permaculture AND education permaculture

Mushroom cultivation in forest farming (FI)

"ecosystem service* indicator" "provisioning services" "regulation and maintenance" "cultural services" "human nutrition" "biodiversity" "social-wellbeing"	AND	"mushroom cultivation" "forest farming" AND mushroom

Certification, production techniques, Community-Supported Agriculture (CSA)(BE)

"ecosystem service* indicator" "provisioning services" "regulation and maintenance" "cultural services" "human nutrition" "biodiversity" "social-wellbeing"	AND	"Community supported agriculture" certify* AND organic AND farming

Note that in some search engines it may be necessary to repeat the searches with the terms in different formats (eg. agro-forestry and agroforestry; wood fuel and woodfuel). Other search terms may also be needed based on knowledge of the subject and national literature on the topic.

Optionally (if time allows), in addition to the literature search, national stakeholders (experts: e.g. researchers, academics, extension services, companies/farmers with expert knowledge) can also be contacted and asked whether they are aware of useful reports, websites or other areas that may list useful indicators or information that could be used to derive indicators – recommended best management practices, for example, or important/indicator species (flora or fauna) that should be present. These recommendations should be incorporated into the literature review.

The results of the literature search should be summarised in a Google spreadsheet. using the format shown in Table 1 below. If possible, they should also be allocated to the appropriate CICES framework "section" (provisioning, regulation and maintenance, cultural (Figure 1). From this, a provisional selection of indicators (up to c.12 under each section) will be selected to be integrated in the PG tool. Indicators will be selected following a Delphi process. The protocol for this provisional indicator selection will be updated in November 2021 and opinions on the process to be applied would be welcomed.

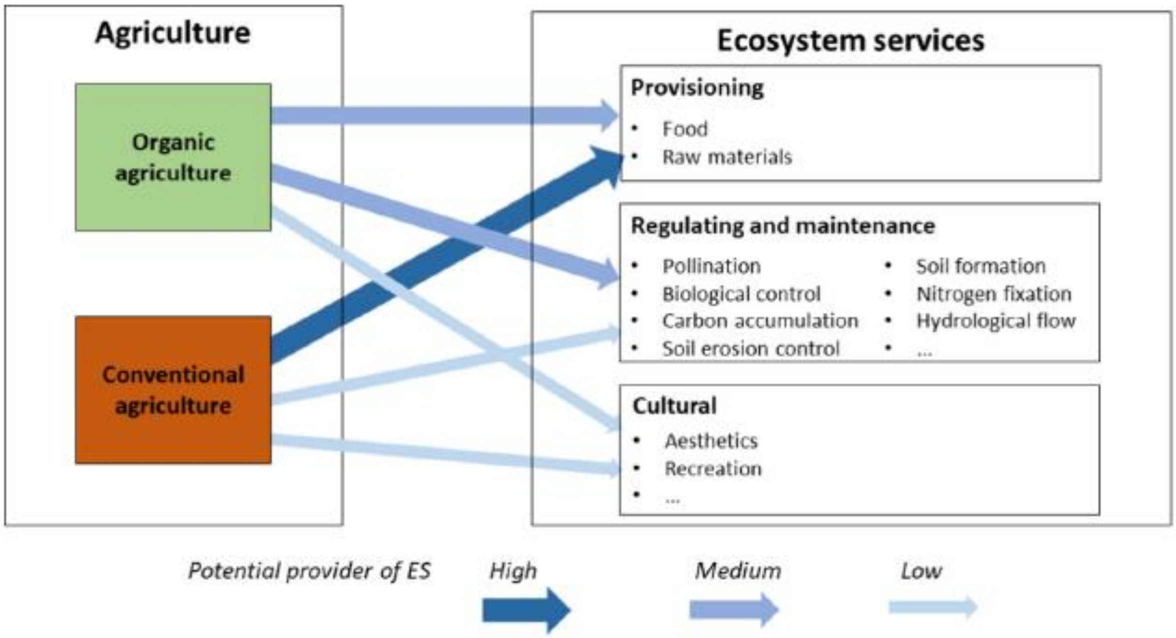

Figure 1. Supply of ecosystem services by agro-ecosystems. Ecosystem services are classified according to CICES. Figure source: Boone et al. 2019.

The results of the literature review will be included in milestone 2.1 *PG tool adapted* (M14) and for feed-in to Task 2.1 Ecosystem Service Assessment. The report will include:

- a description of the search method – databases searched, other sources of literature, search terms used (covered by these guidelines);
- a description of the indicator selection criteria (covered by the protocol to be provided in December 2021);
- a list of the indicators that have been identified as a result of the literature review;
- an initial shortlist of indicators to take forward to the prioritisation exercise with stakeholders;
- a reference list.

Timeline

- Literature review (including optional expert consultation) ready: 31st of May
- Online-indicator survey to **wider group of case study stakeholders**: December 2021
- Indicator workshop with **core group of case study stakeholders**: December-January 2021
- Indicator selection for inclusion in PG tool by **case study partners**: January 2022
- Milestone 2.1 PG tool adapted: M14, 31 January 2022

4. Life cycle and emergy assessment (Task 2.2)

This task analyses the environmental sustainability of the case studies identified by an integrated holistic life cycle and emergy assessment (EME). A cradle-to-grave LCA will determine the overall sustainability of the innovative FS in comparison to mainstream organic systems based on data from D1.2 report, and EME will be used for an energy efficiency analysis of the FS.

The LCA compares different environmental parameters (e.g. greenhouse gas emissions, abiotic resource use and land-use) using latest methods (e.g. updated methodologies for GHG accounting, Cain et al., 2019) and incorporating novel indicators for human nutrition, biodiversity and social wellbeing. Indicators will be selected through a structured literature review and through a well-designed Delphi process. EME is used to analyze energy efficiency and sustainability of complex systems by expressing and accounting for different forms of energy on a common physical basis. After accounting for each system, we will use EME indices to assess the share of economic and environmental inputs to determine the sustainability of FS under diverse socioeconomic contexts.

Life Cycle Assessment (LCA) methodology allows assessing the impact of agricultural activities on the environment in a quantitative manner. The assessment of organic, biodynamic and agroforestry farming systems is still a big challenge. Many agricultural resources are self-produced in this type of farms, e.g.: seeds, animals, fertilizers (manure), soil (soil fertility can be increasing/decreasing).

Particularly difficult is choosing a functional unit FU, determining the system boundary, allocation methods for co-products, etc. due to the complexity and interactions between processes at farm level (involving livestock production and/or soil organic matter changes). The FU is typically 1kg of product living farm gate (normalised, e.g. for given humidity level of wheat grain) or 1ha of land used. Most analysis uses system boundary 'from cradle to farm gate'. Use of consistent broad agricultural system Environmental Footprints (EF) boundaries, incorporation of soil emissions and sequestration, and development and use of fine temporal and spatial scale Tier 3 EFs (based on modelling) is recommended (e.g. Petersen et al. 2013).

Common impact categories examined in the agricultural LCA like acidification, eutrophication and climate change are related to use of mineral and natural fertilizers and nutrients balance in soil. The studies comparing organic and conventional farming show that impacts per area are usually less in organic systems. Taking account lower yields more land is required for organic production. Thus, it may have a greater impact on the environment per product (Meier et al., 2015). The approach must take into account the fact that different products are actually assessed (e.g. how to compare milk from cows grazing all year (free range) with milk of cows fed purchased feeds; can the average consumer feel the difference in taste?). It seems that a more appropriate approach is to assess the environmental impact of farms producing comparable products. Regarding organic farming, there is a need to use expanded boundaries to include not only the commonly considered fertilizer, fuel, and electricity, but also farm infrastructure and machinery, pesticides and other chemical inputs, plastics and other materials, land-use change, soil emissions and C sequestration, and livestock enteric fermentation (Adewale et al. 2018). Moreover, expanding the available Tier 3 Environmental Footprints simulation for agricultural materials overall and organic inputs in particular will improve accuracy and consistency of GHG emission assessments. Nevertheless, more precise definition of temporal and spatial boundary add complexity to GHG assessments and pose many challenges.

In order to estimate holistic environmental sustainability of food systems, full recognition of agricultural functions behind commodities provision is necessary. Agricultural production delivers to society bundles of ecosystem services, so the impact should be allocated among the whole set of agricultural outputs (Boone et al. 2019). The authors compared the environmental impact of conventional and organic agriculture for the same basket of products based on production data available in Life Cycle Assessment (LCA) Ecoinvent databases and quantified the overall resource consumption by accounting provisional and regulating ecosystem services (ES) for all exergy extracted from nature contained in the natural resources used throughout the supply chain (Cumulative Exergy Extraction from Natural Environment (CEENE (2013) method). Allocation factors were developed for both farming systems types, following their capacity to supply ES. It was concluded that for about half of the studied food products (including maize, potato), organic farming has clear environmental benefits in terms of resource consumption in comparison to conventional cultivation methods.

It seems that due to higher production costs, organic farms producing many products such as fruit, nuts, meat etc. should operate in the shortened value chain. This avoids negative environmental impacts associated with the transport and storage of products (e.g. cold stores) and it reduce both food and packaging waste (Mottershead and Schweitzer, 2018).

Life Cycle Assessment requires a lot of quantitative information from the farm. Necessary information that can be collected through on-farm surveys is listed below:

- Main product (s): growing area, yield / amount of milk / live weight of animals at farm gate, etc.
- Land use change in last 5 years (forest <-> arable, pasture <-> arable, etc ...)
- Information on carbon-accumulating landscape elements, such as trees, hedges, field bushes (area, density)
- Soil (type, ph)
- Catch crops, cultivation system (till, reduced till, no-till), management of crop residues
- Seeds (quantity)
- Natural or mineral fertilizers (quantity)
- Plant protection products (quantity)
- Field operations: cultivation, sowing, fertilization, plant protection, crop care, harvesting (hours, fuel)
- Water and energy consumption for irrigation.

In the case of livestock production, the following information will additionally be collected:

- Herd description (number of animals purchased, sold, average, mortality, etc ...)
- Information on how many days in a year (percentage) the animals are grazed, etc ...
- Data on animal feed broken down into own or purchased feed (type of feed, quantity)
- Data on the amount and method of waste management (weight / volume, method of storage)
- General information on buildings and infrastructure (area, volume, materials, year of construction)
- Water consumption in livestock buildings and total water consumption on the farm.
- Energy consumption in livestock buildings and total energy consumption on the farm.

The data needs requirements will be updated regularly during the process of data collection, due to farms complexity and uncertainty of control data availability/quality. The calculation methodology to be selected in next months of the project, this is strongly depending on data problems encountered in LCA farms assessment.

Emergy evaluation (EME), unlike most of the other environmental assessment tools, adopts a nature-centered viewpoint, focusing on the resources used up by a human system (an activity, a territory) and considering it as embedded within its natural environment. Emergy is defined as the direct and indirect energy of one kind to produce a product, resource or service (Odum, 1996) and measured in solar emergy Joules (solar emjoule or sej). Since the concept originates from systems ecology, the EME of a human activity emphasizes more on calculating the emergy value of locally available natural resources. Given the complexity of their production chain, the characterization in emergy terms of man-made resources produced elsewhere and used up by the activity (e.g. human labor and commodities) suffers from a low level of accuracy. Despite the valuable paradigm shift emergy brings about, further efforts are needed to make it a more popular tool for environmental sustainability (Hau and Bakshi, 2004).

EME takes a donor-side approach oriented to consider the natural mechanisms that form the resources. Hence, it is complementary to LCIA methods and somehow advantageous in providing an overall characterization of renewable resources as well as non-renewable ones and ES. EME shares many similarities with the broader LCA framework: it has been demonstrated that the two approaches are complementary and can be combined (Brown et al., 2012; Ingwersen, 2011; Raugei et al., 2014). By integrating emergy within LCA (Raugei et al., 2014), it was shown that emergy could provide a complementary indicator for resources, as 'a unified measure of the provision of environmental support, and an indication of the work of the environment that would be needed to replace what is consumed' (Raugei et al., 2014). EME could also benefit from the detailed description of the network of industrial and agricultural processes and the exchanges of energy and materials among them (the so-called technosphere) that LCA practitioners use to build the Life Cycle Inventory (LCI) of the functional unit under study. The LCI represents the cumulated amount of elementary flows (resources and emissions) exchanged between the technosphere and the natural environment.

When applied to a local activity, EME calculates the unit emergy value (UEV) of the output by accounting for all resources needed by the activity to be operational. These resources are natural, locally available (R and N, for renewables and non-renewables, respectively), or man-made (so-called 'feedback inputs', F). F inputs include materials and energy transformed into useful goods within the technosphere, and non-material services and labor. The underlying philosophy of the emergy approach is to assess the role of natural resources in supporting human systems (activities, economies, territories). Therefore, EME gives a particular importance on depicting natural mechanisms responsible for the formation of R and N resources. Oppositely, the usual practice is to use simplified representations of the F inputs, for instance by attributing them the UEV of the corresponding natural resource (e.g. the UEV of limestone for lime product). When their contribution is assumed to be important, the transformation steps are roughly estimated (e.g. production of an electricity mix: Brown and Ulgiati, 2002; soda and chlorine production: Campbell and Ohrt, 2009). In contrast, labor and services are usually estimated using the national average of the emergy value of one working-hour or one monetary unit (Odum, 1996).

EME with the help of SCALE software uses the detailed representation of the technosphere provided by ecoinvent® (in principle, other LCI databases could also be used). However, it calculates the emergy of the system's output by rigorously applying the emergy algebra to the detailed network of technological processes. The software SCALE requires a preliminary modification of allocation values originally set in the ecoinvent® multi-output processes (see supporting information of Marvuglia et al., 2013a, for details). Then it applies a backtracking algorithm to trace flows of energy and materials within the modified network and to avoid double-

counting. According to the rules of emergy algebra, the output emergy value is lower than (or equal to) the total emergy value of inputs. The difference depends on the number of feedback loops in the network of processes. An important consequence is that the level of details in the representation of processes influences the resulting emergy value of outputs (TirutaBarna and Benetto, 2013). To avoid infinite calculation time, a threshold (named minflow) on the value of the flow tracked by SCALE must be set by the user (hereafter called Minflow). A high threshold value (e.g. 0.1 Msej) would lead to the omission of important feedback loops, while a low threshold value (say lower than 1E−6 Msej) would increase computation time drastically with a negligible loss of information (named emergy lost in Marvuglia et al., 2013a).
SCALE allows a rigorous calculation of the emergy of any product or service. The emergy calculation algorithm has been released as OpenSource. SCALE uses data coming from any available life cycle inventory database. It is the first software allowing an exact calculation of emergy. It allows an operational integration between life cycle assessment and emergy.

5. Socio-economic value chain (Task 2.3)

This task aims to analyse the different value chain linkages within the food systems of the seven national case studies identified. Particularly it will examine:

1) added value activities (incl. knowledge production and ecosystem service provision);
2) complexities of production networks and innovation activities (network analysis);
3) relationship of actors in the chain (incl. decision making strategies and governance);
4) embeddedness to identify specific regional mechanisms.

To investigate the input-output structures along the innovative value chains a qualitative research design will be applied. As food production systems as well as innovations comprise also various intangible (co-)processes such as the (re-)configuration of social practices or relationships between the actors involved, the research design chosen is particularly suitable to explore these phenomena. Qualitative in-depth case studies provide detailed insights into the structures and functioning underlying the object of study by looking at an individual case and thus help to gain a better understanding (Baxter 2010: 81-82). It allows not only to uncover the context-specific conditions in which the respective food system is embedded in and within which actors in the chain (inter)act, but also to highlight the subjective perceptions and opinions of the interviewees (Mattissek et al. 2013: 127-128).

Data for the value chain analyses will be collected in semi-structured qualitative interviews with the case studies' farmers and stakeholders involved in their food systems. The approach to carry out the data collection for this task should consider the guidelines explained in the following sections.
In addition to the qualitative information on the Social Return on Investment (SROI) (Nicholls et al. 2012) that will be covered by the interviews, further quantitative indicators (e.g. initial investment) are needed to calculate the SROI. These will be included to the PG-tool (linkage to Milestone 2.1: PG-Tool adapted).

1. Sampling strategy: How to identify interview partners?

The starting point for identifying interview partners has already been set out within the first stages of the project (Task 1.1) whereby the FOODLEVERS Innovative Case studies (FICs) have been carefully selected through an outranking process considering the coverage of the four OECD-areas

of innovation[1]: (1) Products; (2) Production techniques; (3) Marketing; and (4) Organisation and governance.
Following this pre-sampling, the technique of snowball-sampling will be applied as a strategy to identify suitable stakeholders to interview within each national case study. This sampling strategy allows to better grasp the specific nature as well as value chain configuration of each food system.

All partners are asked to recruit suitable stakeholders linked to their case studies. The following procedure is suggested:

1) As the case study is already known, the data collection will start with interviewing **the main production farm(s)**. If the respective case study comprises a network of farmers or collaborates with other farmers several farmers can be interviewed (e.g. 2-4 farms).
2) At the end of the interview, the interviewee is asked for the contact details of the **most important stakeholders involved in their value chain** (suppliers, processors, distribution partners, retailers etc.) as well as some **other relevant stakeholders** (e.g. umbrella organizations, NGOs, local governments, consumer groups etc.). Subsequently, this leads the investigator to the following interviews.

The contact to the potential interviewees will be made either in written (via Email) or oral format (phone call). A template email was provided by UMR in the annex of the interview guidelines.

2. Implementation of Data collection: Conducting qualitative interviews

The data for this task will be collected in semi-structured qualitative expert interviews by the project partners using an interview protocol that was developed by UMR. Therefore, all partners are encouraged to organise appointments for data collection, undertake and record the qualitative interviews. As a result, between **5 to 7 interviews** should be conducted for each case study country.

There are **three different semi-structured interview guidelines** to use depending on the type of stakeholder interviewed:

1) Production farms
2) Stakeholders involved in other parts of the value chain (e.g. processing; supply; distribution; sale; waste management etc.)
3) Other stakeholders (e.g. from policy, umbrella organisations, experts etc.)

The interviews with production farms are foreseen to take longer (between 1 – 1.5 hours) as they are the principal stakeholder group and thus, go more into detail (also depends on how talkative the interviewee is and how much time she/he has), whereas the interviews with the other two groups of stakeholders might be shorter. The interviews can take place in diverse formats such as face-to-face, via telephone or Skype.

The interview guidelines include **metadata forms** which should be filled by the interviewer to note down all aspects known prior to the interview (e.g. function of the interviewee, location and date of the interview etc.). It is advised to avoid writing down any personal data (e.g. the respondent's name) as anonymity should be guaranteed.

[1] https://www.oecd.org/site/innovationstrategy/defininginnovation.htm

In order to start the interview appropriately, an **introductory part** is provided in the header of the interview guidelines. To make the respondent feel comfortable, one can start with thanking her/him that the interview can take place, briefly introducing the project FOODLEVERS and the focus and aim of the interview. Afterwards organizational issues have to be clarified. The interviewer has to ensure anonymity and ask for approval for recording. Then the **recording** of the interview can be started (at best with two advices).

Since the interaction between the interviewer and interviewee is an essential part of the qualitative research process, the sequence of questions and specific question formulation in the interview guidelines can be flexibly adapted. In this way, thematic deviations often arise in the interview (but these can also contain important information!). However, the interviewer should keep an eye on the time and, if necessary, lead back to the subject of investigation to ensure that the obligatory questions are dealt with.

Further instructions on the implementation are given in the interview guidelines.

3. Post-Interviews

After the interviews have been recorded and saved at a safe location, the partners are asked to **transcribe the interviews** in the respective language and translate it **into English**. This should not contain any personal data. After having defined a save way for data exchange, the transcripts should be transferred to the lead-partner of this task (UMR).
For the transcription of the interviews and data transfer UMR will provide additional guidelines to assure data protection.

For the subsequent data evaluation UMR will undertake a **qualitative content analysis**. Within the case-related and subsequent cross-case assessment, the material will be filtered and structured according to its content in line with the analytical frameworks of this task (Global Value Chains (Gereffi et al. 2005), Global Production Networks (Henderson et al. 2002), "deep" leverage points (Abson et al. 2017).

6. Consumer behaviour analysis (Task 2.4)

This task aims to understand consumers' decision-making process in purchasing food in either innovative organic /agroforestry food systems or conventional systems / mainstream organic systems. Consumer behaviours, attitudes and diets will be investigated to understand what information about food production and processing are relevant for them (decision-making processes). This in turn to identify actions and communication strategies towards consumers to induce their behavioural change.
The underlying drivers of behaviour will be assessed based on the Theory of Consumer Behaviour (TPB).
According to the TPB (Ajzen and Kruglanski, 2019) human behaviour is guided by three main beliefs (figure 1):

- beliefs about the likely consequences and experiences associated with the behaviour (**behavioural beliefs**),
- beliefs about the normative expectations and behaviours of significant others (**normative beliefs**),

- beliefs about the presence of factors that may facilitate or impede performance of the behaviour (**control beliefs**).

In their respective aggregates, behavioural beliefs produce a favourable or unfavourable *attitude toward the behaviour*; normative beliefs result in perceived social pressure or *subjective norm*; and control beliefs give rise to *perceived behavioural control* or *self-efficacy*.

As a general rule, the more favourable the attitude and subjective norm and the greater the perceived control, the stronger should be the person's intention to perform the behaviour when the opportunity arises. Intention is thus assumed to be immediate antecedent of the behaviour.

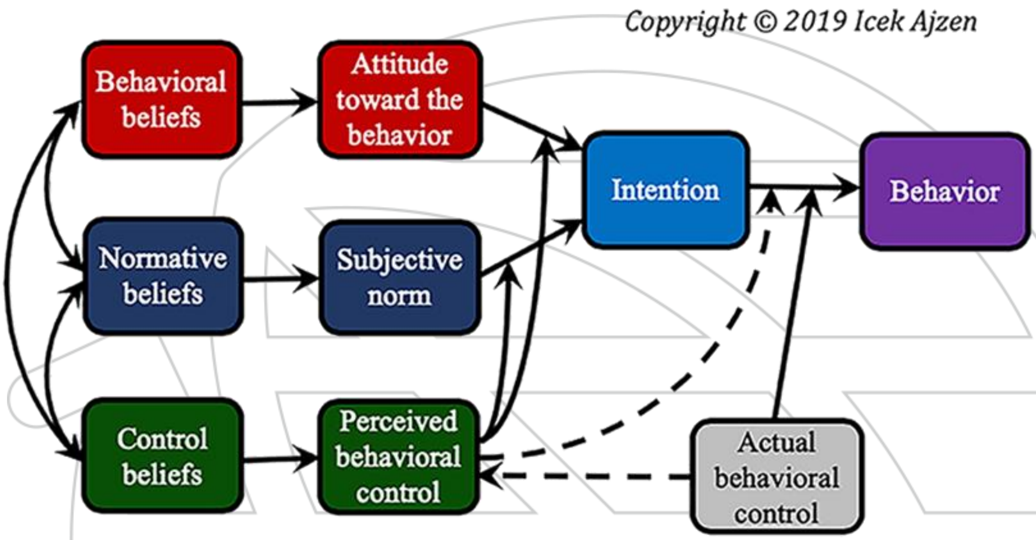

Figure 1: recognized belief that influence human behaviour.

In designing TPB the following steps should be considered:

Variables	Example (hypothesis)
The **expected behaviour** should be carefully defined in terms of target, action, context and time	⇨ Target: consumers ⇨ Action: food consumption ⇨ Context: organic food ⇨ Time: how many times per week
Intention: it can be used as a proximal measure of behaviour	⇨ Intention to increase organic food consumption ⇨ How many times? 3-4 times/week? every day?
Attitudes towards the behaviour: it is a person's evaluation of the behaviour. It is assumed to have two components: belief about the consequences of the behaviour and the corresponding positive or negative effect of the behaviour	⇨ Increase organic food consumption is healthy and safeguard the rural environment

Subjective norms about the behaviour: it is a person's own estimate of the social pressure to perform or not the target behaviour. It has two components: belief about how other people, who may be important for the person, would like to behave and the positive or negative evaluation of the belief	⇨ I feel pressure from my family/friends to increase the consumption of organic food because they think it is healthy and protect the environment
Perceived behavioural control of the behaviour: it is the extent to which a person feels able to enact a behaviour. It has two components: how much a person has control over the behaviour and how confident a person feels about being able to perform a behaviour	⇨ I can't increase the consumption of organic food because it is too expensive ⇨ I would increase the consumption of organic food if I could find organic shop closer to my place

Within this framework, a methodological approach that should be adopted is purposed according to Francis et al., 2004. The queries are reported as example of type of questions.

1. **Measuring behavioural intentions**

The most common used method uses three items to have an adequate **internal consistency**.

Example:

⇨ I expect to increase the consumption of organic food in the next 3 months Strongly disagree 1 2 3 4 5 6 7 strongly agree ⇨ I want to increase the consumption of organic food in the next 3 months Strongly disagree 1 2 3 4 5 6 7 strongly agree ⇨ I intend to increase the consumption of organic food in the next 3 months Strongly disagree 1 2 3 4 5 6 7 strongly agree

2. **Measuring the attitudes**
    a. *Direct measurement of attitude*

- Use bipolar adjectives (good-bad
- Use 4 items following a single stem
- Use both instrumental items (if the behaviour achieves something, e.g. useful-worthless) and experiential items (how it feels to perform the behaviour, e.g. pleasant-unpleasant)
- Arrange the items so that the ends of the scales are a mix of positive and negative

It is important that the attitude items have high **internal consistency**

Example:

⇨ Increase the consumption of organic food is: Harmful 1 2 3 4 5 6 7 beneficial Good 1 2 3 4 5 6 7 bad Pleasant 1 2 3 4 5 6 7 unpleasant Worthless 1 2 3 4 5 6 7 useful

b. *Indirect measurement of attitude*: measuring behavioural beliefs and outcome evaluations

- Conduct an elicitation study to identify the most common beliefs sampling about 25 persons. Use open-ended questions (interviews, focus groups, questionnaires).

Example:

⇨ What do you believe are the **advantages** to consume organic food? Health, safeguard the environment… ⇨ What do you believe are the **disadvantages** to consume organic food? Too expensive, difficult to find….

- Construct questionnaire items to assess the strength of behavioural beliefs. Select the behavioural beliefs most often listed and convert these into a set of statements. These statements should reflect the beliefs which might affect the behaviour of the target population (at least 75% of all beliefs).

Example:

⇨ If I increase the consumption of organic food, I will feel to do something positive for the environment/health Unlikely 1 2 3 4 5 6 7 likely ⇨ To consume organic food will negatively affect my savings Unlikely 1 2 3 4 5 6 7 likely

- Construct questionnaire items to assess outcome evaluations. Convert each of the belief statements into the form of an incomplete sentence in order to allow the participants to express a positive or negative evaluation of the belief statement

Example:

⇨ Doing something positive for the environment is: Extremely desirable -3 -2 -1 0 +1 +2 +3 extremely undesirable ⇨ Spending higher price for food is: Extremely desirable -3 -2 -1 0 +1 +2 +3 extremely undesirable

3. Measuring the subjective norms

a. Direct measurement

- Direct measurement involves the use of questions referring to the opinions of important people in general

Example:

⇨ Most people who are important for me (relatives, friends, colleagues…) think that I should increase the consumption of organic food Strongly disagree 1 2 3 4 5 6 7 strongly agree ⇨ It is expected of me that I should increase the consumption of organic food Strongly disagree 1 2 3 4 5 6 7 strongly agree ⇨ I feel social pressure to increase the consumption of organic food Strongly disagree 1 2 3 4 5 6 7 strongly agree

b. Indirect measurement of subject norm: measuring normative beliefs and motivation to comply

- Conduct an elicitation study to identify the most common beliefs sampling about 25 persons. Use open-ended questions (interviews, focus groups, questionnaires).

Example:

⇨ Are there any individuals or groups who would **approve** you increase the consumption of organic food ⇨ Are there any individuals or groups who would **disapprove** you increase the consumption of organic food

- Construct questionnaire items to assess the strength of normative beliefs. Select the groups or individuals most often listed and convert these into a set of statements. These statements should reflect the groups or individuals which might affect the behaviour of the target population (at least 75% of all beliefs). Items may reflect what important people think a person should do (*injunctive norms*) or what important people actually do (*descriptive norms*).

Example: imagine that the elicitation study has identified three sources of social pressure: relatives, friends, colleagues

Injunctive items (what important people think I should do) ⇨ My relatives think that I should increase the consumption of organic food Strongly disagree -3 -2 -1 0 +1 +2 +3 strongly agree ⇨ My friends would approve if I will increase the consumption of organic food Strongly disagree -3 -2 -1 0 +1 +2 +3 strongly agree *Descriptive items (what important people actually do)* ⇨ My colleagues don't consume organic food Strongly disagree -3 -2 -1 0 +1 +2 +3 strongly agree

- Convert each sources of social pressure into the form of a statement about the importance of the various sources of social pressure

Example:

⇨ My relative's approval is important to me Not at all 1 2 3 4 5 6 7 very much

⇨ What my friends think I should do matters to me Not at all 1 2 3 4 5 6 7 very much ⇨ Doing what my colleagues do is important to me Not at all 1 2 3 4 5 6 7 very much

4. **Measuring perceived behavioural control (PBC)**

   a. *Direct measurement of PBC*

- Items should reflect people's confidence that they are capable to perform the target behaviour. This can be achieved assessing the person's self-efficacy and their beliefs about controllability of the behaviour
- Self-efficacy is assessed by asking people to report:
  - How difficult it is to perform the behaviour
  - How confident they are that they could do
- Controllability is assessed by asking people to report:
  - Whether performing the behaviour is up to them
  - Whether factors beyond their control determine their behaviour

Example:

Self-efficacy ⇨ I'm confident that I could increase the consumption of organic food if I want Strongly disagree 1 2 3 4 5 6 7 strongly agree ⇨ For me to increase the consumption of organic food is Easy 1 2 3 4 5 6 7 difficult *Controllability* ⇨ The decision to increase the consumption of organic food is beyond my control Strongly disagree 1 2 3 4 5 6 7 strongly agree ⇨ Whether I increase the consumption of organic food or not is entirely up to me Strongly disagree 1 2 3 4 5 6 7 strongly agree

   b. *Indirect measurement of PBC: measuring control beliefs and their perceived power to influence the behaviour*

- Conduct an elicitation study to elicit commonly held beliefs: identify the content of control beliefs which are shared by the target population about the behaviour. Construct questionnaire to assess the strength of these control beliefs and the pawer of these control factor to influence the behaviour. Sample of 25 people. Content analyse the information into themes (control beliefs) and order and label the themes extracted. List the themes in order from the most frequently mentioned to least frequently mentioned

Example:

⇨ What factors or circumstances enable you to increase the consumption of organic food? ⇨ What factors or circumstances make it difficult or impossible to increase the consumption of organic food? ⇨ Are there any other issues that come to mind when you think to increase the consumption of organic food?

- Construct questionnaire items to assess the strength of the control beliefs. Select the beliefs most often listed and convert them into a set of statements. These statements should reflect the beliefs which might make it difficult to perform (or not perform) the target behaviour. Inclusion of 75% of all beliefs.

Example: imagine that the elicitation study has identified 3 control beliefs: organic food has a good taste, organic food is too expensive; organic food is difficult to be found in the shop

⇨ I will increase the organic food consumption because the good taste
Unlikely 1 2 3 4 5 6 7 likely
⇨ I will not increase the consumption of organic food because the high costs
Unlikely 1 2 3 4 5 6 7 likely
⇨ I will not increase the consumption of organic food because I can't find at the shop closer to my home
Unlikely 1 2 3 4 5 6 7 likely

- Construct a questionnaire items to assess the power of these factors. Convert each control belief into a form of an incomplete statement about whether this makes it more or less likely that a person will do the target behaviour, or whether it makes the behaviour easier or more difficult to do

Example:

⇨ When I consume organic food I'm happy
Less likely -3 -2 -1 0 +1 +2 + 3 more likely
⇨ If I buy organic food I can't buy other goods
Less likely -3 -2 -1 0 +1 +2 + 3 more likely
⇨ When I want to by organic food I have to travel too much
Less likely -3 -2 -1 0 +1 +2 + 3 more likely

7. Stakeholder decision making model (Task 3.1)

This task will map actors' knowledge and perceptions in a Fuzzy Cognitive Map (FCM). FCM develops a behavioural 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 and economic changes and to develop adequate policy actions and mitigation/adaptation strategies.

Fuzzy logic Cognitive Map (FCM) 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 (Jetter & Kok, 2014).

FCM can be implemented adopting the following framework that consists of six steps:

- ***Clarification of project objectives*** and information needs (**Step 1**). This step includes the definition of the scope of the modelling project, including its topic, model boundaries, and the timeframe under consideration. Furthermore, open questions about the knowledge domain are identified.

- ***Plans for knowledge elicitation*** (**Step 2**). This modelling step requires the identification of knowledge sources, as well as the planning the knowledge elicitation techniques to be used.
- ***Knowledge capture*** (**Step 3**). This process step includes all elicitation activities that lead to (weighted) causal cognitive maps about the knowledge domain. In addition, information about the expected dynamic behaviour of the system they represent is collected to enable model tests in Step 6.
- ***Post-processing*** (**Step 4**) ***calibration and detailed*** (**Step 5**) ***design of the FCM model***, include the translation of the causal cognitive map captured in Step 3 into an adjacency matrix, the choice of output functions and input vectors, and approaches to dealing with time lags.
- ***Model use and Interpretation*** of model results (**Step 6**).

1. Definition of FCM objectives

The first step to FCM construction is a thorough analysis of the model's objectives.
In order to clarify the objectives of a modelling project, modellers 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. This ensures the identification of the model elements and stakeholders, whose views and knowledge may be important for the model.
A potential pitfall of the first modelling step is to specify objectives in a manner that restricts the input of the stakeholders. Once the model objectives are known, model boundaries – the variables that should be excluded from the model or considered to be exogenous – should be assessed and documented in a model boundary chart.
Also, all information needs that become apparent during the goal analysis should be documented, preferably as question. Finally, the timeframe (present situation, developments in the next 2 years, situation in 10 years, etc.) of the analysis needs to be clarified.

2. Plans for knowledge elicitation

The decision whose domain knowledge should be used for the FCM model is closely intertwined with the decision on how expert knowledge should be captured. Respondents can be identified through snowball sampling, stakeholder analysis and organizational network analysis, but may also be predetermined by the client of the modelling project. To overcome individual biases, FCM models should rely on several respondents. The number of respondents needed depends on the complexity of the issue and the diversity of opinions: in recent multi stakeholder studies, between 7 and 46 individual cognitive maps were captured (Hossain & Brooks, 2008; O¨ zesmi & O¨ zesmi, 2004; Rodriguez-Repiso, et al., 2007; van Vliet, 2011). Each respondent can be expected to introduce 15–30 concepts, many of which will be shared with other respondents. New respondents should be surveyed as long as their input still introduces relevant new concepts and connections to the study.

Three different methods for knowledge elicitation are used in the FCM literature.

- Option 1 – The modeller is the expert
- Option 2 – The modeller surveys the expert(s)
- Option 3 – The modeller analyzes documents

In our case, option two is the suggested method; surveys can take the form of questionnaires and semi-structured, face-to-face interviews or the form of Delphi-studies, and moderated group discussions in which respondents take up and integrate contrasting views. Survey designs with group interaction 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, particularly if emphasis is put on understanding the rationale behind outlier models, as is common in Delphi studies. Multi-stakeholder studies employ cognitive mapping as a survey approach that focuses respondents' attention on a knowledge domain and captures respondent knowledge in great depth.

3. Knowledge capture - approaches to cognitive mapping

Knowledge capture activities should help respondents to challenge their mental models and improve their subjective theories. To achieve these objectives, causal cognitive mapping typically follows three basic steps:

- respondents are briefly trained in cognitive mapping,
- identify concepts that pertain to the knowledge domain in question (capture of knowledge content)
- document their causal knowledge in ''loop and arrow'' diagrams (capture of knowledge structures).

After that, it is recommended to capture the casual connections and their weight in sequence steps to avoid high cognitive demanding.

Respondents interact with the interviewer and each other using a workshop setting, facilitated by the FCM modeler, in which the respondents communicate about their ideas and draw a group cognitive map together.

Creating cognitive maps in a group setting point out that individuals benefit from new ideas and insights gained from other respondents. The joint mapping process may thus facilitate a higher-order learning that would be impossible to achieve in individual interviews.

Cognitive mapping and modelling of FCMs can be supported with a software. Mental Modeler (Gray, Cox, & Henly-Shepard, 2013) allows us to build Fuzzy-logic Cognitive Maps easily and intuitively. Once models are built, increasing or decreasing the components included in the model allows you to examine different scenarios of change. Areas of agreement or disagreement can be used to improve collective understanding and also to identify "leverage points" in the system.

The mathematical integration of individual cognitive maps requires some upfront work, such as the clarification of concept meanings and standardization of concept names. Furthermore, when respondents characterize the same concept as concept and dis-concept (e.g. ''political stability'' and ''political instability'') one of the concepts needs to be converted. To preserve the direction of

causality, the converted concept's connecting arrow needs to be changed to the opposite direction.
To achieve standardization and integration it is possible combines the concepts mentioned in individual cognitive maps into categories that represent a larger encompassing variable. Integration can be supported by analytical methods for comparing cognitive maps and identifying areas of agreement and disagreement among the respondents. A simple form of text mining can be useful for creating a standard dictionary that contains key concepts and their synonyms.
Cognitive mapping needs to start with a dedicated knowledge activation step. This can occur by providing a list of clearly described key terms that are relevant to the problem domain as a stimulus or, alternative approaches to knowledge activation are the presentation of initial causal models or guided discussions with respondents.
To enable standardization and integration of the concepts mentioned by individual respondents, concept meanings needs to be clear. In an interactive workshop setting, clarification of terminology can occur through a plenary discussion during which participants can communicate effectively before each concept is defined in detail and the exact nature of concepts is captured.
Skilled and knowledgeable facilitation can correctly guide this process but care should be taken not to focus too much on reaching a complete and shared verbal description of what the concepts represent because discussions on details can turn into an unproductive debate on semantics that is of little value to the participants.
To elicit causal knowledge structures the respondents have to arrange concepts on a work surface spatial organization of concepts (whiteboard, desk, paper, or computer screen depends the way the workshops will organized (on-line, in presence…) and to move, drop, and add cards and add causal links between them until they are satisfied with the layout.
Once causal links between concepts are established, respondents add concept signs (+ or -) to indicate positive or negative causality. It is advisable to only offer positive and negative linear causality as modelling option. It means that in case of "U-shaped causality" (''Fertilizing the field increases yield until it is too much and over-fertilization damages the soil''), it has to be expressed in a linear fashion (''Fertilizing the field increases yield, over-fertilizing the field decreases yield'').
Once the type of causal link is defined, respondents give causal weights, giving numerical values for link strength in the range of [-1;1].
The last step of the capture of knowledge on the dynamic behaviour of the system should provide information on how the respondents expect the system to behave dynamically, at least for key variables that are well understood. This knowledge is used in later stages of the FCM-modelling process to test if the FCM model's system behaviour reflects the respondent's expectations and may lead to additional respondent insights, such as the realization that feedback loops exist or important concepts are missing.

4. Post-processing: model adjustment

The causal maps that are generated during cognitive mapping need to be translated into adjacency matrices in order to create an FCM model. However, the initial FCM as drafted by stakeholders frequently needs to be adjusted to enable proper FCM computation and meaningful model interpretations.

- In general, when respondents include concepts that are excluded in the model boundary chart or link concepts to exogenous variables, these concepts and causal links must be deleted.

- Respondents sometimes explain those aspects of the knowledge domain that they consider particularly important or difficult to understand in much greater detail than other areas. Causal maps therefore must be checked for potential definitional causal links: when they are strictly definitional they need to be eliminated.
- Respondents sometimes include concepts in their causal maps that have no ‘‘Out’’-arrows, even though they are clearly not a target concept. This is usually an indicator for incomplete or faulty knowledge capture. In some cases, however, these concepts are diagnostic variables – they are causally connected to the same concepts that influence the target concepts, but independent from the latter and give information about the state of the system. If chosen wisely they can give valuable information for the calibration of the FCM.
- Some causal relations are conditional: Concept A (‘‘Rain’’) and Concept B (‘‘Temperatures below 0 8C’’) cause Concept C (‘‘Slippery road’’) to happen. FCMs need to reflect this either by making sure that the threshold of the activation function of concept C can only be met by A and B together.
- If respondents draw causal links with very different timeframes, such as months versus years, these time frames have to be synchronized through so-called ‘‘dummy concepts’’. These concepts are inserted in the more long-term causal link to break it up into several causal links with shorter time-frames. Sometimes mismatches in timeframes are even larger and slow variables like climate change can be renamed in a faster variable like ‘drought’.

5. FCM calibration and testing

The objective of FCM modelling for future studies is not to create a ‘‘true’’ model, but a useful and formalized description of the perception of a group of people, such as subject matter experts or stakeholders, of the problem at hand. A disagreement between the FCM model’s behavior and the behavior that the respondents expect of the model can lead to important insights and does not have to lead to modifications of the model. Instead, respondents may gain insights into their own mental models and accept the model results. Conversations between the modeller and the respondents are a powerful means to help decide if the unexpected behavior is an FCM model flaw or if the modelled system can be expected to behave that way. The main pitfall when using calibrated FCM is the temptation to see their predictions as the truth about how the future will unfold, when what they truly provide are alternative and often competing ideas on ways in which it may unfold.

6. FCM model use and interpretation

The steps for FCM modelling above are applicable to any FCM modelling project that relies on the capture and integration of knowledge from multiple respondents, such as stakeholders and experts. FCM simulation are used as the basis for further discussion, contrasted against stakeholder opinions, and compared to already existing scenarios in order to provide the input for quantitative scenarios.

8. Agent based model (Task 3.2)

The main aim of this task is to provide a holistic view of the complex agri-food system and its interactions between socio-economic, ecological and behavioural aspects within different actors. To provide such analyses, Agent-Based Modelling (ABM) will be the main used method.

To parametrize these agents in the model, several quantitative and qualitative data must be collected from interviews, participatory sessions and workshops, including data from all the previous tasks.
As reported in M1.3, since the ABM is supposed to be at a system-level, we propose the following structure:

- **Farms and Farmers**: The data about farms and farmers can be coming from the results of Task 2.1, 2.2, 2,3 and 3.1. More precisely, the PGT can provide detailed multi-criteria knowledge at a farm level. LCA and EME could highlight the sustainability and environmental aspects of the farms and their value chains. VCA could give a qualitative understanding of the actors' behaviours including farmers with respect to their value chain and innovation. Last but not least, FCM provides decision-making scenarios of various stakeholders including farmers.

- **Consumers**: The data about the consumers can come from Task 2.3 and 2.4. In this respect, VCA provides knowledge on the stakeholders' behaviours within their value chain including consumers associated with the case studies. TPB's main outcome is around the identification of consumers' motivations, behaviours, principles, beliefs and rules toward sustainable organic consumption. The identified rules and principles of consumers can be used directly as an input into the agent-based model simulating a heterogeneous group of consumers.
- **Other actors**: Regarding other actors, mainly Task 1.2, 2.3, 3.1 can provide information for the ABM. In this regard, RS provides general data and knowledge on how is the current configuration of the current system is and what are the main actors in addition to farmers and consumers. These actors could be of different kinds including retailers and policymakers. VCA and FCM include other actors too while highlighting their decision-making models and behaviours, which could be used in the ABM.
- **Macro-level data:** To understand the model baseline, macro level data should be collected. In this regard, Task 1.2 guides and supports the collection of different datasets related to the different countries involved in FOODLEVERS project. Those national-level data can be used to show the current trends (baseline) in the organic sector.

9. Qualitative scenario modelling (Task 3.3)

The main goal of this task is to qualitatively project the effect of the identified leverage points on the transformation of the food systems in future. This task should be viewed as an outlook at the end of the project aiming to define a common perspective and a shared vision among all the stakeholders contacted and involved in the 3 years project.
In doing so, participatory workshops with external experts (from agriculture, nutrition, sustainability) and the stakeholders from the innovative case studies will be organized in each partner country. The scenario workshops will be based on common guidelines developed by UMR, reflecting the results on deep leverage points generated within the project. During these workshops, the participants will be provided with information as a sort of inputs which they will need to be able to formulate futuristic scenarios. Such inputs that have been gathered in the common guidelines are technically all levers identified throughout the project.

The workshop might possibly be divided into the following two parts:

(1) **Scenario field analysis:** In collaboration with the scientist(s) leading the workshop, the participants will cluster the leverage points presented to them by scoring the key levers. Subsequently, these key levers are linked to different scenario-based assumptions, e.g:
   - *Scenario 1:* all key levers will improve substantially
   - *Scenario 2:* levers will not improve
   - *Scenario 3:* only certain levers will improve

(2) **Scenario Building:** Within a snowball-method the participants will project possible developments of the different scenario-based assumptions, first in small groups (e.g. 2 people) then together with all participants. In addition, policy recommendations for future changes towards sustainable food production can be derived by defining also boundaries of future-oriented pathways of food systems.

Hence, the results of the previous tasks will be further analysed and selected and will be used in the workshops in order to develop what/if scenarios to build corridors for future developments towards sustainability, working as guidelines for policy makers.
The subsequent results of the workshops will be summarised in a scenario modelling report (D3.3), based on the common guideline (M3.3) provided by UMR.

10. References

Abson, D.J., Fischer, J., Leventon, J., Newig, J., Schomerus, T., Vilsmaier, U., Wehrden, H. Von, Abernethy, P., Ives, C.D., Jager, N.W., Lang, D.J. (2017). Leverage points for sustainability transformation. Ambio 46, 30–39. https://doi.org/10.1007/s13280-016-0800-y.

Adewale, C., Reganold, J. P., Higgins, S., Evans, R. D., & Carpenter-Boggs, L. (2018). Improving carbon footprinting of agricultural systems: Boundaries, tiers, and organic farming. Environmental Impact Assessment Review, 71, 41-48.

Ajzen, I., Kruglanski, A. W. (2019). Reasoned action in the service of goal pursuit. *Psychological Review, 126*(5), 774–786. https://doi.org/10.1037/rev0000155.

Baxter, J. (2010): Case Studies in Qualitative Research. In: Hay, I. (eds.): Qualitative Research Methods in Human Geography, 81-97.

Bjørn Molt, P., Trydeman, M., Erik Hermansen, J., Halberg, N. (2013). An Approach to Include Soil Carbon Changes in Life Cycle Assessments". Journal of Cleaner Production 52: 217–24. https://doi.org/10.1016/j.jclepro.2013.03.007.

Boone, L., Roldán-Ruiz, I., Muylle, H., Dewulf, J. (2019). Environmental sustainability of conventional and organic farming: Accounting for ecosystem services in life cycle assessment. Science of the Total Environment, 695, 133841.

Brown M.T., Raugei M., Ulgiati S. (2012). On boundaries and investments in emergy synthesis and LCA: a case study on thermal vs. photovoltaic electricity. Ecol Indic 15:227–35.

Brown M.T., Ulgiati S. (2002) Emergy evaluations and environmental loading of electricity production systems. J Clean Prod 10:321–34.

Campbell D.E., Ohrt A. Environmental accounting using emergy: evaluation of Minnesota. USEPA project report (2009). EPA/600/R-09/002; 2009.

Earles, J. Mason, Halog, A. (2011). Consequential Life Cycle Assessment: A Review". The International Journal of Life Cycle Assessment 16 (5): 445–53. https://doi.org/10.1007/s11367-011-0275-9.

FAO. (2018). Sustainable food systems Concept and framework. https://www.fao.org/3/ca2079en/CA2079EN.pdf.

Francis, J., Eccles, M. P., Johnston, M., Walker, A. E., Grimshaw, J. M., Foy, R., Kaner, E. F. S., Smith, L. and Bonetti, D. (2004). Constructing questionnaires based on the theory of planned behaviour: A manual for health services researchers. Newcastle upon Tyne, UK: Centre for Health Services Research, University of Newcastle upon Tyne.

Gereffi, G., Humphrey, J., Surgeon, T. (2005): The governance of global value chains. Review of International Political Economy 12:1 February 2005: 78–104.

Gray, S. A. S., Cox, L. J., & Henly-Shepard, S. (2013). Mental modeler: A fuzzy-logic cognitive mapping modeling tool for adaptive environmental management. Proceedings of the 46th annual Hawaii international conference on system sciences (pp. 965–973).

Hau J.L., Bakshi B.R. (2004). Promise and problems of emergy analysis. Ecol Model 178: 215 25.

Ingwersen W.W. (2011). Emergy as a life cycle impact assessment indicator. J Ind Ecol 15: 550 67.

Henderson, H., Dicken, P., Hess, M., Coe, N., Wai-Chung Yeung, H. (2002). Global production networks and the analysis of economic development. in: Review of International Political Economy 9:3 August 2002: 436– 464

Hossain, S., & Brooks, L. (2008). Fuzzy cognitive map modelling educational software adoption. Computers & Education, 51, 1569–1588.

IPCC Guidelines for National Greenhouse Gas Inventories (2006). Volume 4. Agriculture, Forestry and Other Land Use. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm.

Jetter, J.; Kok, K. (2014). Fuzzy Cognitive Maps for futures studies — A methodological assessment of concepts and methods, Futures vol. 61, pag. 45–57. ISSN 0016-3287, https://doi.org/10.1016/j.futures.2014.05.002

Marvuglia, A., Benetto, E., Rios, G., Rugani, B. (2013). SCALE: Software for CALculating Emergy based on life cycle inventories. Ecol Model; 248:80–91.

Mattissek, A., Reuber, P., Pfaffenbach, C. (2013): Methoden der empirischen Humangeographie. 2. Auflage.

Meier, M.S., Stoessel, F., Jungbluth, N., Juraske, R., Schader, C., Stolze, M. (2015). Environmental Impacts of Organic and Conventional Agricultural Products – Are the Differences Captured by Life Cycle Assessment?" Journal of Environmental Management 149: 193–208. https://doi.org/10.1016/j.jenvman.2014.10.006.

Mottershead, D. and Schweitzer, J.P. (2018). Short food supply chains. Briefing for the report: Unwrapped: How throwaway plastic is failing to solve Europe's food waste problem (and what we need to do instead). Institute for European Environmental Policy (IEEP), Brussels. A study by Zero Waste Europe and Friends of the Earth Europe for the Rethink Plastic Alliance.

Nicholls, J., Lawlor, E., Neitzer, E., Goodspeed, T. (2012): A guide to Social Return on Investment. Retrieved from http://www.socialvaluelab.org.uk/wp-content/uploads/2016/09/SROI-a-guide-to-social-return-on-investment.pdf

Odum H,T, (1996). Environmental accounting: emergy and environmental decision making. John Wiley & Sons Inc.; 1996.

O¨zesmi, U., O¨ zesmi, S. L. (2004). Ecological models based on people's knowledge: a multi-step fuzzy cognitive mapping approach. Ecological Modelling, 176, 43–64

Raugei M., Rugani B., Benetto E., Ingwersen W.W. (2014). Integrating emergy into LCA: potential added value and lingering obstacles. Ecol Model 271:4–9.

Rodriguez-Repiso, L., Setchi, R., Salmeron, J. L. (2007). Modelling IT projects success with Fuzzy Cognitive Maps. Expert Systems with Applications, 32, 543–559.

Tiruta-Barna L., Benetto E. (2013). A conceptual framework and interpretation of emergy algebra. Ecol Eng 53:290–8.

Van Vliet, M. (2011). Bridging gaps in the scenario world: Linking stakeholders, modellers and decision makers. Wageningen: Wageningen University