ERA-NET Cofund on Sustainable Crop Production

- SusCrop -

Report on Task 7.4

Workshop on ‘sustainability’ and ‘resilience’ assessment methods

Organised by the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO)

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Task 7.4 Workshop on ‘sustainability’ and ‘resilience’ assessment methods

Content

1 Introduction

With this workshop, the SusCrop ERA-net wanted to offer an opportunity to its partners and project executers to acquire more insight in some assessment methods, which they might want to use in their current or future projects. Within SusCrop we thus want to contribute to the common knowledge on what agricultural sustainability is and how it can be assessed, and support project executers to demonstrate what the contribution of their project to sustainability is.

The workshop was organised on September 10th, 2019, at the Flanders research institute for agriculture, fisheries and food (ILVO) in Melle, Belgium. It was part of a three days event, set back-to-back with the projects' kick-off meeting and the task 7.3 workshop.

2 Preparatory surveys

In order to determine the appropriate knowledge transfer for the workshop, we sent out two small questionnaires, one to the SusCrop partners (funders) and one to the researchers involved in the SusCrop projects (project coordinators and partners). The questionnaires sounded out the respondents' ideas about "sustainability" and "resilience", the importance they attach to sustainability assessment and their preference for the type of assessment.

1. The partner questionnaire was sent out on 03/12/2018 and closed 28/01/2019. It reached a 38% response rate.
2. The researcher questionnaire ran from 27/02 to 31/05/2019 and had a 51% response rate.

2.1 Sustainable crop production definition

The first question in the both surveys was

"How do you define 'sustainable' crop production?".

The wording used by the SusCrop partners' while answering this question is represented in Figure 1. Many partners define sustainability as only being about environmental issues, about half of them also talk about the economic and social dimensions. One very broad definition stated: "Crop production that does not impair future crop production". This is an example of food for thought at the workshop, as failures in the agricultural system's economics, ecosystem, social acceptability and governance could all cause treats to future crop production.

Figure 1 Word cloud representing the wording by SusCrop partners when defining sustainable crop production

In the researchers answers there were two main keywords: environment and resources/inputs (Figure 2). Looking more closely at the themes they use (Figure 3), following themes are predominant: reducing pressure from crop production on the environment, maintaining or increasing crop production and/or food security, while using less non-renewable inputs, i.e. increasing production efficiency, and increasing ecosystem service provision. Economic aspects were mentioned 8 times (16 %, either alone or integrated with environmental and social aspects. Social aspects got mentioned by only 10 % of the researchers.

Given these results, the workshop will need to emphasise the need for systems thinking and the role of farmers, agro-food chain players and citizens in sustainable crop production systems.

Figure 2 Word cloud representing the wording by SusCrop researchers when defining sustainable crop production

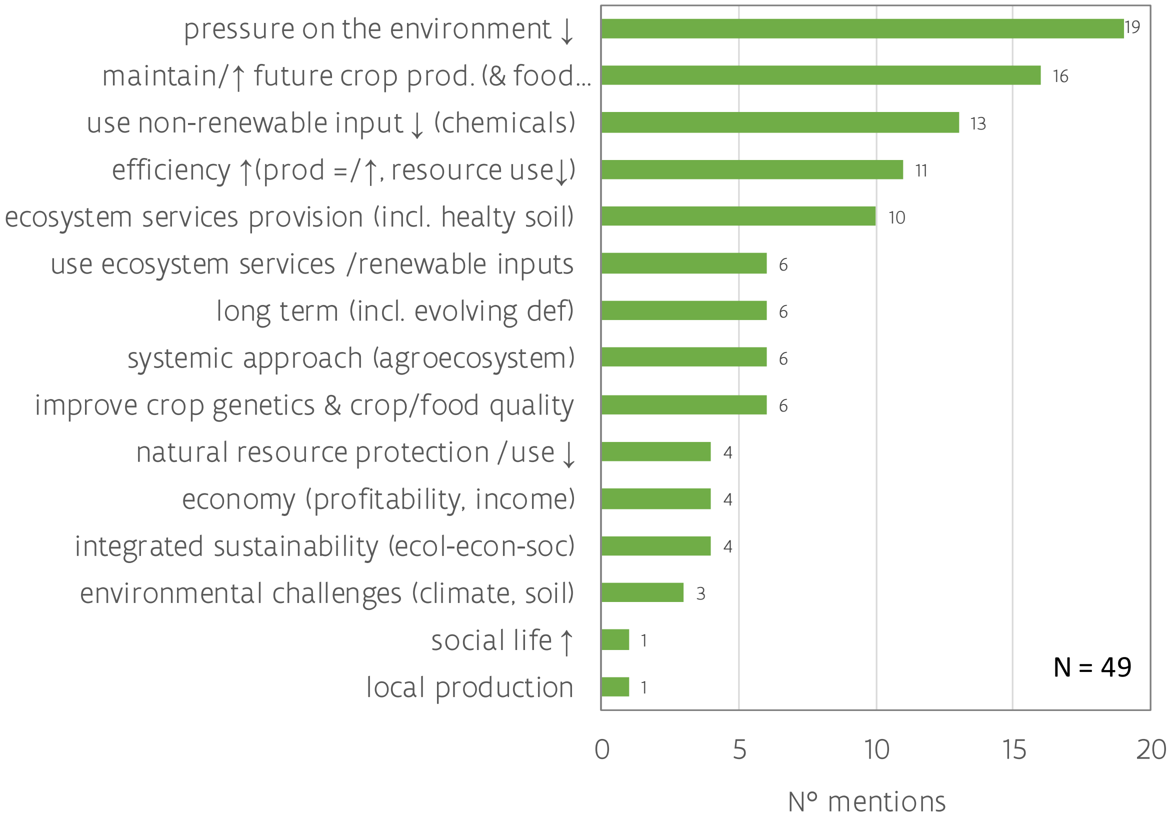

Figure 3 Concepts used by SusCrop researchers when defining sustainable crop production

2.2 Resilient crop production definition

The second question in the both surveys was "How do you define 'resilient' crop production?". In their answer, the SusCrop partners mainly talked about recovering from changing production conditions, often mentioning climate change (Figure 4). The researchers use similar definitions, often specifying that crops should be able to withstand stress, either of biotic or abiotic nature (Figure 5 and Figure 6). Farm economic resilience, in the sense of adequate investments, vulnerability to price volatility or social change, etc., was only mentioned by one partner, who said "[...] *& also insurances and collectives of farmers helping each other can be useful*".

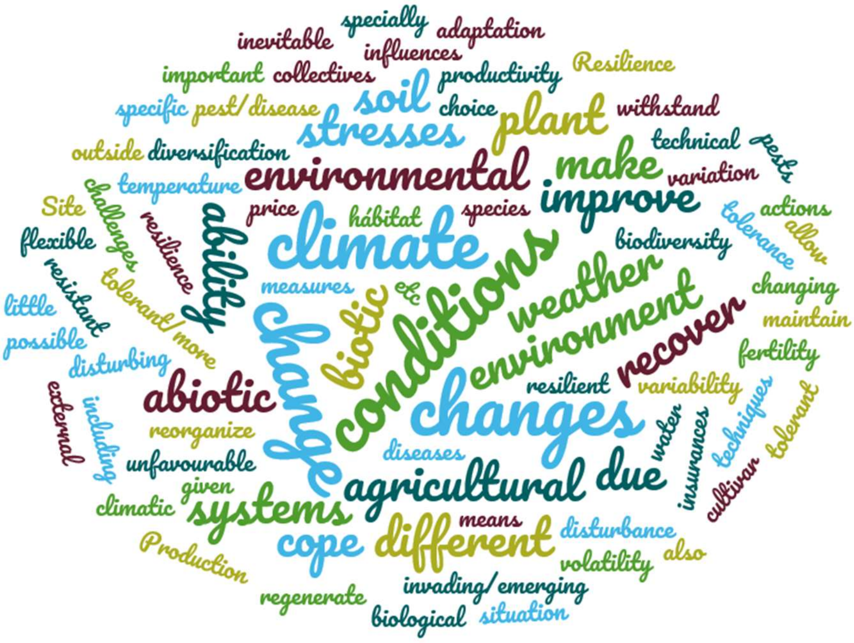

Figure 4 *Word cloud representing the wording by SusCrop partners when defining resilient crop production*

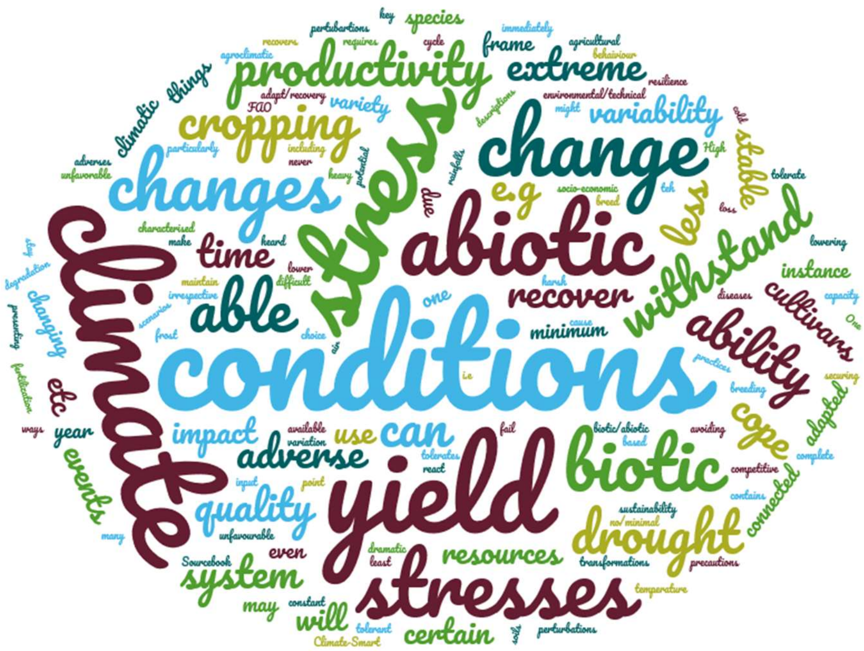

Figure 5 *Word cloud representing the wording by SusCrop researchers when defining resilient crop production*

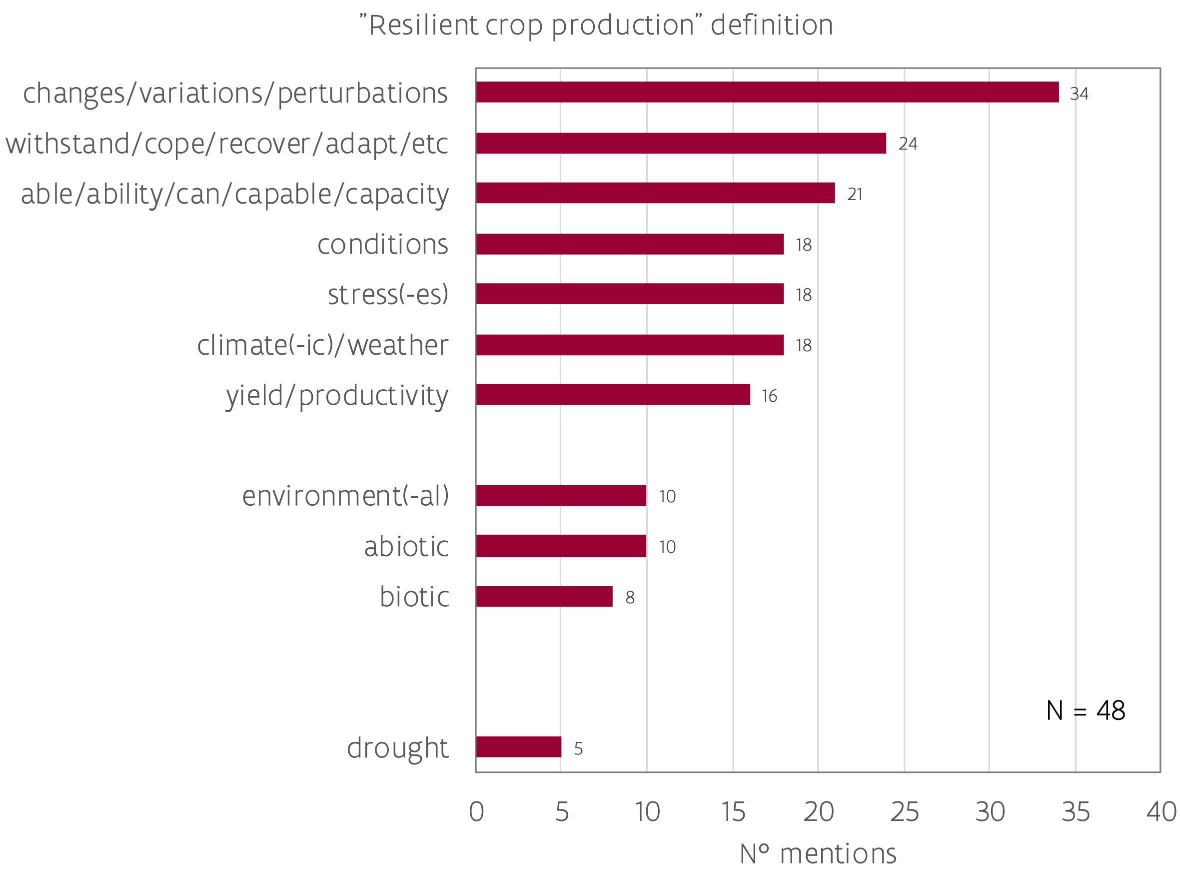

Figure 6 Words used by SusCrop researchers when defining resilient crop production

The stated definitions are thus quite close to the general FAO definition: "Resilience is the ability of people, communities or systems that are confronted by disasters or crises to withstand damage and to recover rapidly". The Horizon 2020 project SureFarm (https://surefarmproject.eu) specified the definition for agricultural systems: "Systems are resilient if they have the capacity to adapt to changing circumstances and challenges while maintaining their core functions, including the delivery of their vital goods and services." They go on saying that resilience means "maintaining the essential functions of EU farming systems in the face of increasingly complex and volatile economic, social, environmental and institutional challenges". The same dimensions are thus defined for "resilience" as for "sustainability". Moreover, to assess the resilience of farming systems SureFarm decided to use sustainability indicators, measured over a long term.

Given these developments, the workshop may be limited to "sustainability assessment methods".

2.3 Importance of sustainability assessment and willingness to assess

The SusCrop partners (funders) expressed a large support for sustainability assessment (Figure 7). Also the SusCrop researchers expressed overall expressed willingness to assess sustainability and/or collect the necessary data in their project (Figure 8). Some researchers say "no", however. Potential reasons for this may be

- lack of budget foreseen. Some researcher comment on this and indeed the first SusCrop call for projects did not foresee any sustainability assessment.

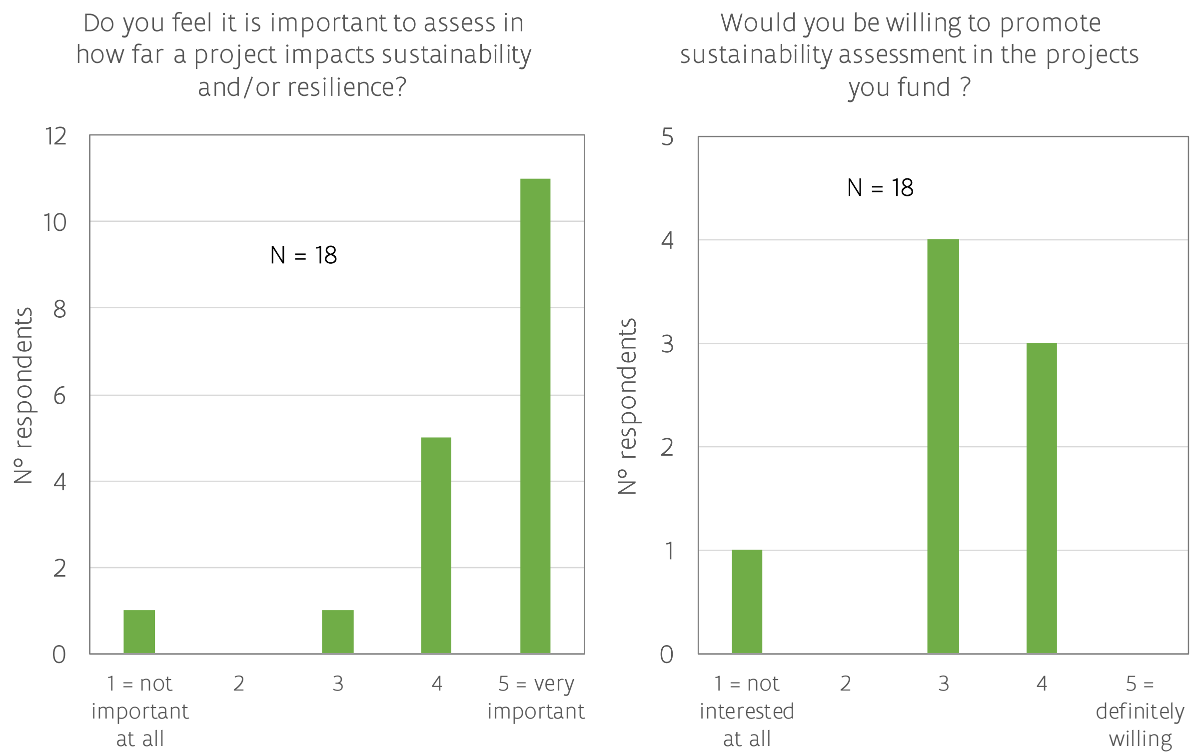

Figure 7 Importance attached to sustainability assessment (left) and willingness to promote it (right) expressed by SusCrop partners

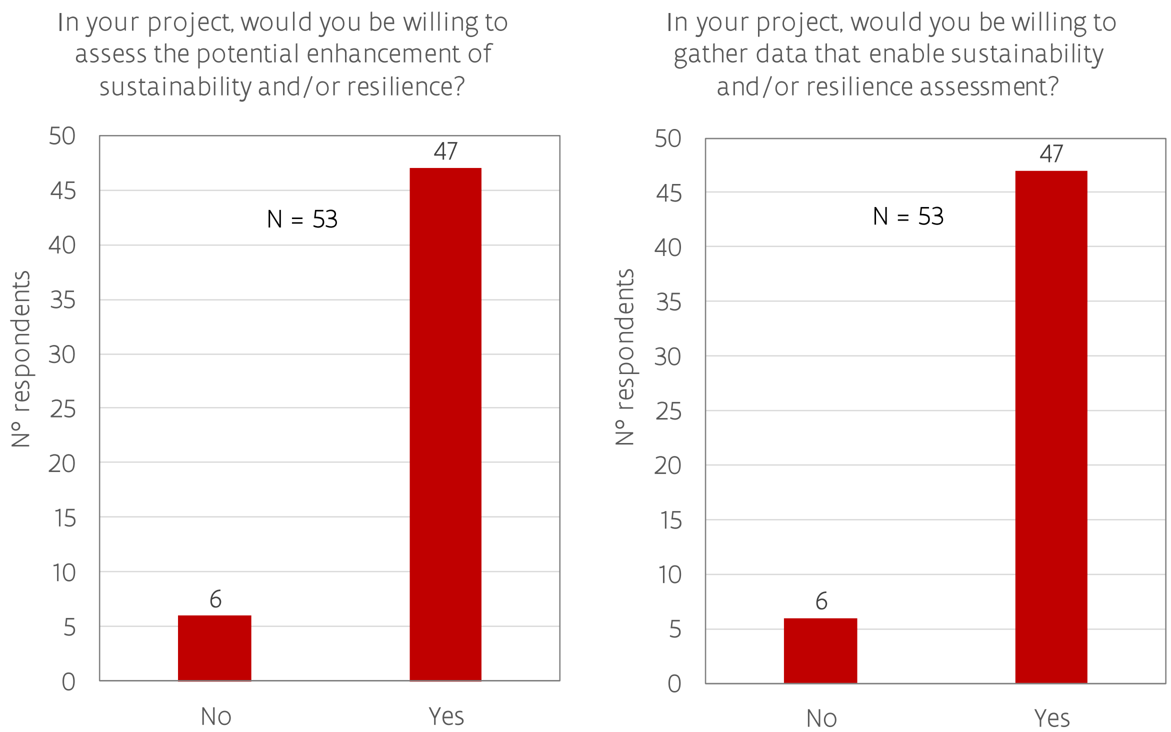

Figure 8 Willingness to assess sustainability (left) and to collect the necessary data (right) expressed by the SusCrop researchers

- impact only foreseen long after finishing the project. Being asked "When do you expect an impact of your project's results on applications for agricultural sustainability or resilience (in case your proposed project is successful)?", 11 researchers answered "after 6-10 years" and 3 say "after more than 10 years". Only 5 researchers expected an impact during the lifetime of the project (Figure 9). Within projects, some disagreement on this period was found though.
- the respondent's role in the project. All that said "no" are partners in the projects, not coordinators. If one/some partner(s) in a certain project said "no", there always were others that said "yes". Some projects contain a work package on sustainability assessment, usually specific partners are responsible for this WP. The assessments foreseen in the projects include a cost-effectiveness analysis in AC/DC-weeds; an integrated sustainability analysis, exploring environmental, economic and social sustainability effects in LegumeGap; and a sustainability assessment next to a life cycle analysis in NETFIB.

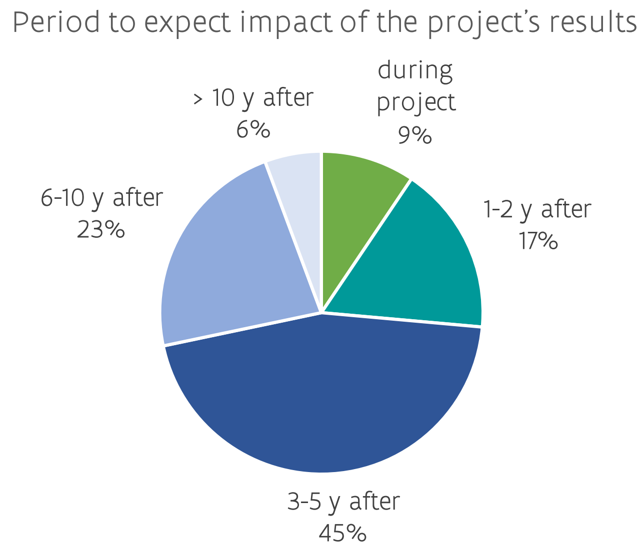

Figure 9 Period within which SusCrop researchers expect an impact of their project's results on applications for agricultural sustainability or resilience (in case the proposed project is successful)

2.4 Type of sustainability assessment

Most SusCrop partners clearly prefer a quantitative indicator based sustainability assessment, although some have no particular preference for this type over qualitative expert judgement (Figure 10). The SusCrop researchers, by contrast, are mostly willing to collect both quantitative and qualitative data to feed sustainability assessment (Figure 11).

The September 10th workshop covered both quantitative and qualitative methods for sustainability assessment. SAFA and SMART use both quantitative and qualitative data to assess farms or food chains, DEXiPM uses qualitative expert judgement, while life cycle assessment is a purely quantitative method.

Given the rather low technology readiness level stated for a number of projects (Figure 9), the workshop organisers explicitly chose to include MASC and DEXiPM, as these methods were developed for *ex ante* assessment of changes to the cropping system and can thus support the design of innovative systems.

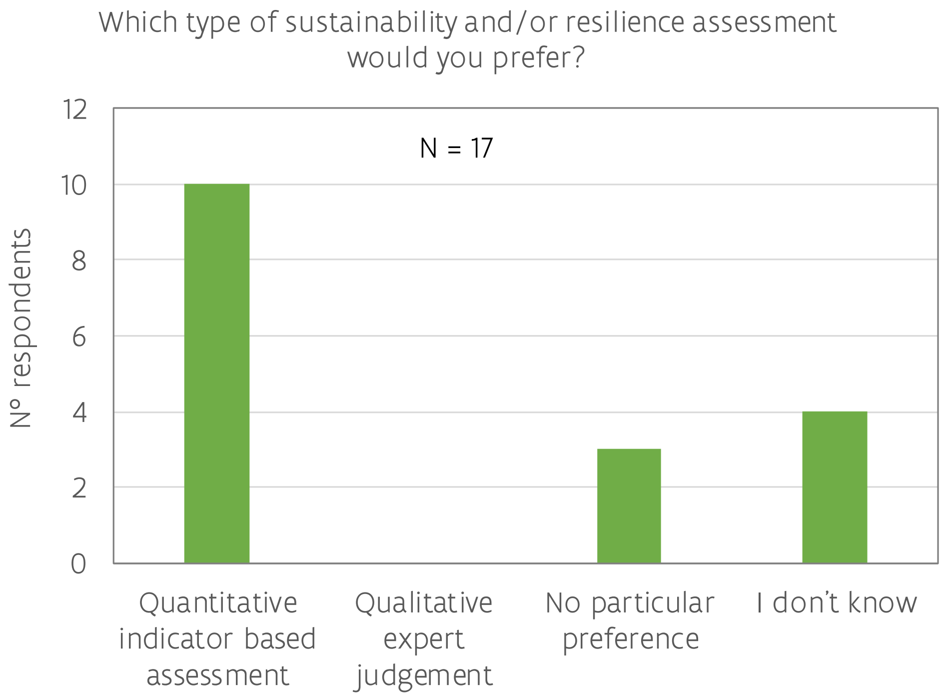

Figure 10 Preference of the SusCrop partners concerning the type of sustainability assessment

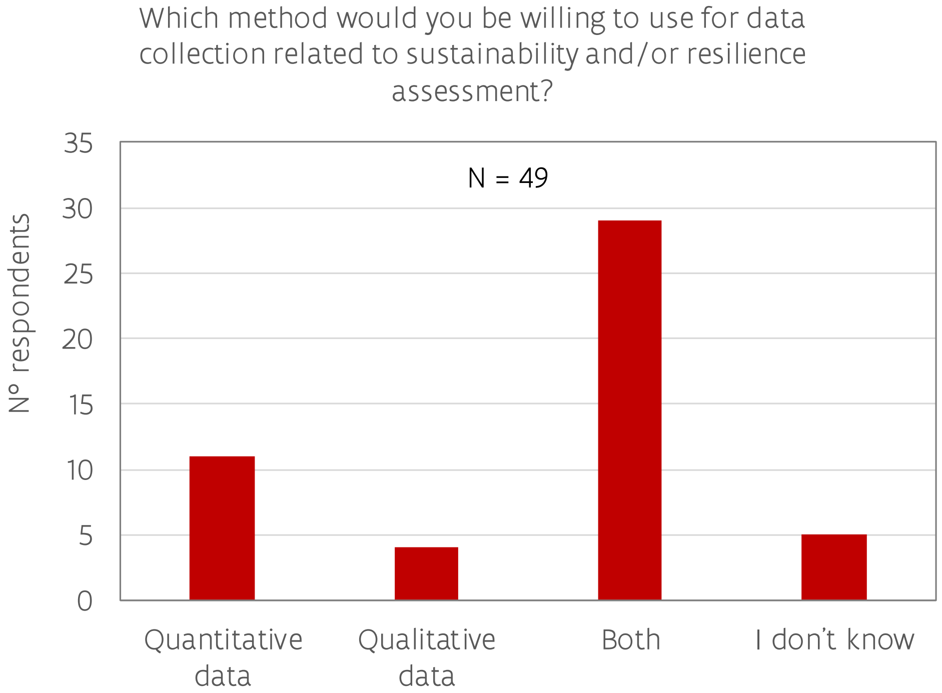

Figure 11 Willingness of the SusCrop researchers to collect data for sustainability assessment

2.5 Knowledge of sustainability assessment tools

Finally, the questionnaire sounded out the knowledge of existing sustainability assessment tools. Less than half of the SusCrop partners and researchers could name relevant frameworks, methods or tools (Figure 12).

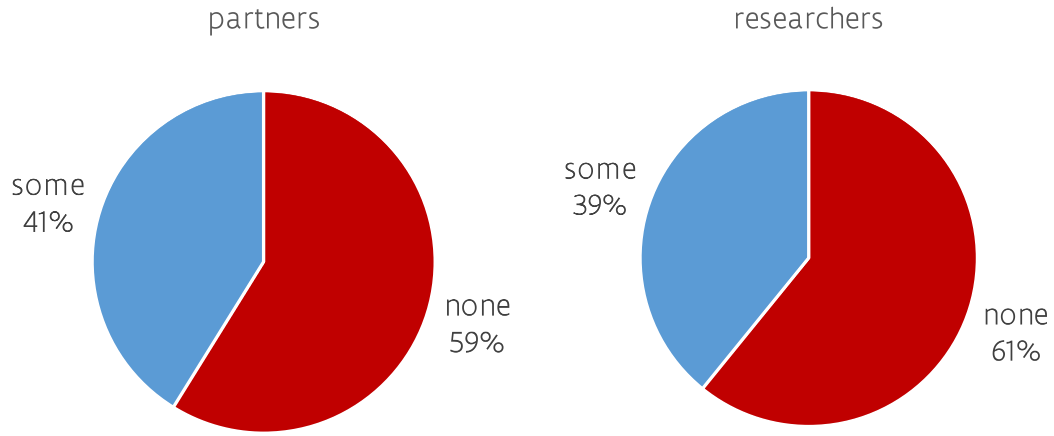

Figure 12 Share of SusCrop partners (left) and researchers (right) that, when asked "Which sustainability and/or resilience assessment frameworks, methods or tools do you know for the farm level?" answered "none" or gave a relevant answer in the "the following" box (coded here as "some")

In total only 25 out of 71 respondents provided a relevant answer to the question which sustainability assessment tools they knew for the farm level. The partners and researchers that did provide "some" answer, often gave multiple answers. They mentioned a wide range of indicator sets, frameworks and tools, as shown in Figure 13 and Figure 14. In both groups, life cycle assessment is the best-known tool, but also several integrated (multi-criteria) frameworks or tools were mentioned.

2.6 Conclusion from the preparatory surveys

The results of the preparatory surveys show that the knowledge level on sustainability assessment of the SusCrop partners and researchers is very variable. "As varied as the project's subjects" one might say. Part of the partners and researchers have a very good knowledge of sustainability assessment, whereas the majority have limited knowledge.

The appropriate knowledge transfer for the workshop thus seems to be to start the plenary part of the workshop at a basic level, emphasising the need for systems thinking and the role of farmers, agro-food chain players and citizens in sustainable crop production systems. Also the differences in purpose, level and scopes when assessing sustainability should be treated and the appropriate tools for each of them. The plenary part can then continue to treat some different types of integrated sustainability assessment tools, while highly complex tools, such as LCA, can be discussed in a specific focus group during the final session.

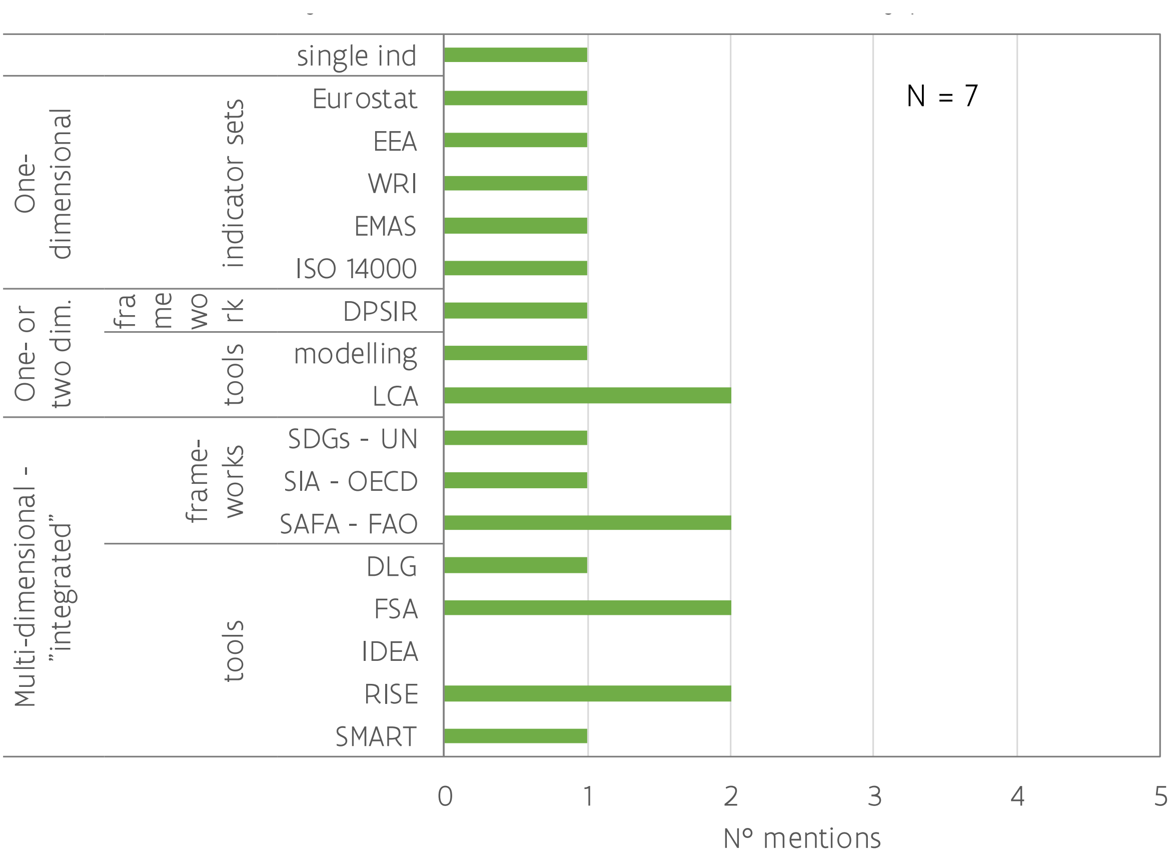

Figure 13 Sustainability and/or resilience assessment frameworks, methods or tools for the farm level mentioned by SusCrop partners

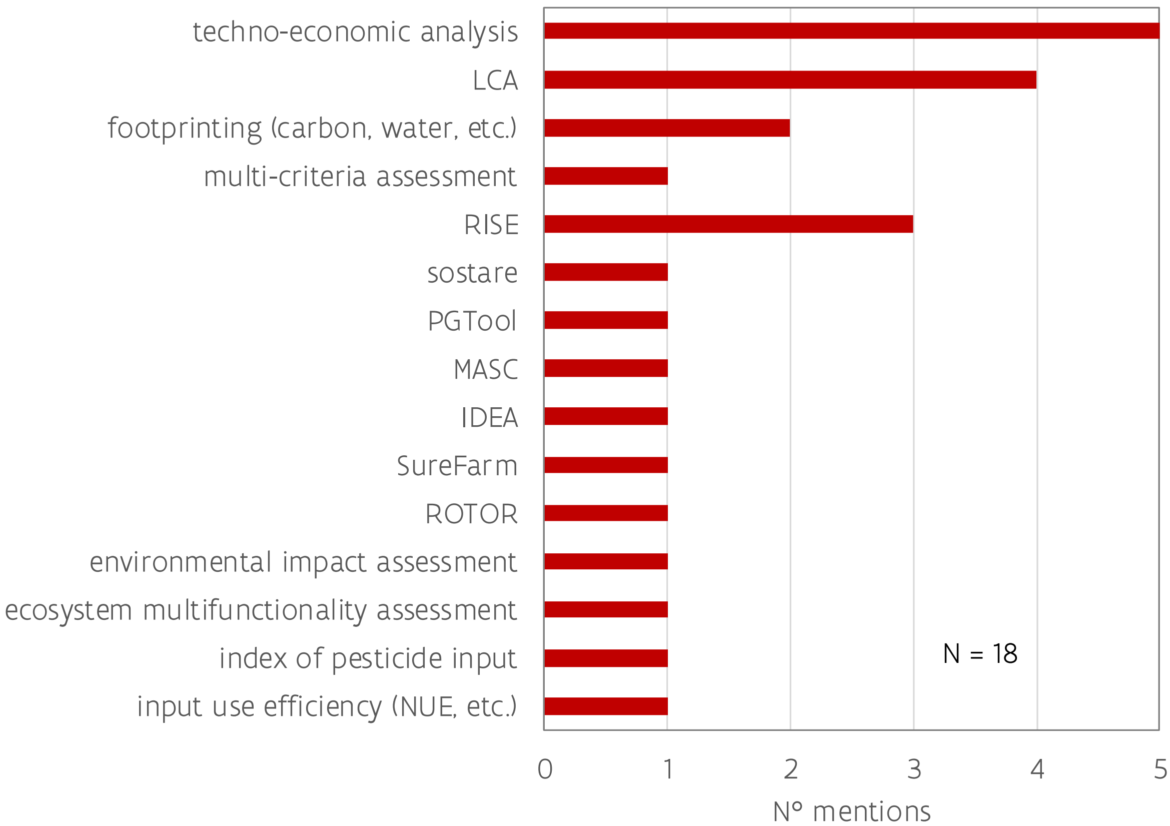

Figure 14 Sustainability and/or resilience assessment frameworks, methods or tools for the farm level mentioned by SusCrop researchers

3 The workshop on September 10th, 2019

3.1 Workshop programme

Meeting venue: ILVO – Plant, Caritasstraat 39, 9090 Melle

WORKSHOP "Sustainability and resilience assessment methods"		
12:00 – 12:30	PART 1: The need for systems thinking in sustainability ▪ Introduction to the workshop ▪ Setting the scene: Sustainability Assessment of Food and Agriculture systems	Johannes Pfeifer (BLE) Hilde Wustenberghs (ILVO) Nadia El-Hage Scialabba (FAO)
LUNCH		
13:30 – 14:55	PART 2: Tools for sustainability assessment ▪ Sustainability assessment methods: SMART, LCA and modelling ▪ Novelties in Life Cycle Assessment ▪ DEXiPM-MASC and their use to help design cropping systems	Christian Schader (FiBL) Veerle Van Linden (ILVO) Frédérique Angevin (INRA)
HEALTH BREAK		
15:15 – 17:00	PART 3: Tools (continued) ▪ Is there a need for harmonisation in SA tools? ▪ Visions for sustainability assessment uptake Group discussions 1. Life Cycle Assessment 2. Multi Criteria Assessment at farm level	Ine Coteur (ILVO-KUL) Sergiu Didicescu (EIP-Agri) Keynote speakers & all participants
17:00 – 17:15	Plenary wrap up WORKSHOP 1 PART 1-2-3	Group rapporteurs

Figure 15 Participants to the workshop (Photograph Louise Pauwels, ILVO)

3.2 Summaries of plenary presentations

SusCrop is about Sustainable Crop Production. But wat exactly does this entail? How is sustainable crop production defined? In the preparatory survey, respondents mainly talked about "reducing pressure from crop production on the environment, and maintaining or increasing crop production and/or food security, while using less non-renewable inputs" (see section 2.1). Sustainable crop production was also defined as "Crop production that does not impair future crop production" (adapted from the Brundtland[1] definition). In her introduction to the workshop, Hilde Wustenberghs, stated that "when thinking about what might impair future crop production, this could be polluting the environment, in which crop production takes place. But maybe also the low prices that are paid for agricultural crops, which may cause farms going out of business, and the extremely long hours that farmers often work and the huge stress they are often under, might also impede the next generation to start farming. Therefore we should also take the human factor into account when we define sustainable cropping."

The first two speakers in the workshop emphasised the need for systems thinking in sustainability assessment, i.e. for taking all dimensions of the system into account. They then went on to introduce some tools that were developed for sustainability assessment (SA) in agriculture. Also the third and fourth speaker continued on different types of tools. Both life cycle assessment and multi-criteria assessments were introduced. The fifth and sixth speaker emphasised the implementation of SA tools at the farm level.

3.2.1 Sustainability Assessment of Food and Agriculture systems - Nadia El-Hage Scialabba (FAO)

Nadia El-Hage Scialabba is an ecologist with 33 years of progressive experience as Environment and Sustainable Development Officer at the Food and Agriculture Organization of the United Nations. She conceived, developed and implemented environment and sustainable development assessment approaches and methods including: sustainable agriculture and rural development (SARD), greening the economy with agriculture (GEA), sustainability assessment of food and agriculture systems (SAFA) and full-cost accounting. She implemented policy and technical projects in Asia and the Pacific, Africa, Central Europe and Caribbean and actively participated in inter-governmental environmental groups and UN committees of food system governance.

Nadia started her talk by emphasising that the environment is indeed only one pillar of sustainable food and agriculture systems. The FAO considers four dimensions:

- Environmental integrity
- Economic resilience
- Social well-being
- Good governance

For each of these four dimensions the essential elements are outlined in a number of themes (21 in total), e.g. for the environmental dimension these are atmosphere, water, land, biodiversity, materials and energy, and animal welfare (Figure 16). The themes are further divided into 58 sub-themes, e.g. for atmosphere: greenhouse gases and air quality.

When are these (sub)themes considered sustainable? E.g. how far does socially "sustainable" go? Livelihood for FAO should not be "minimal", but "decent". These (sub)themes are dynamic and influence each other (trade-offs), e.g. if it is about farmers, when a type of production gives a decent income, more farmers come in that production system and prices might drop.

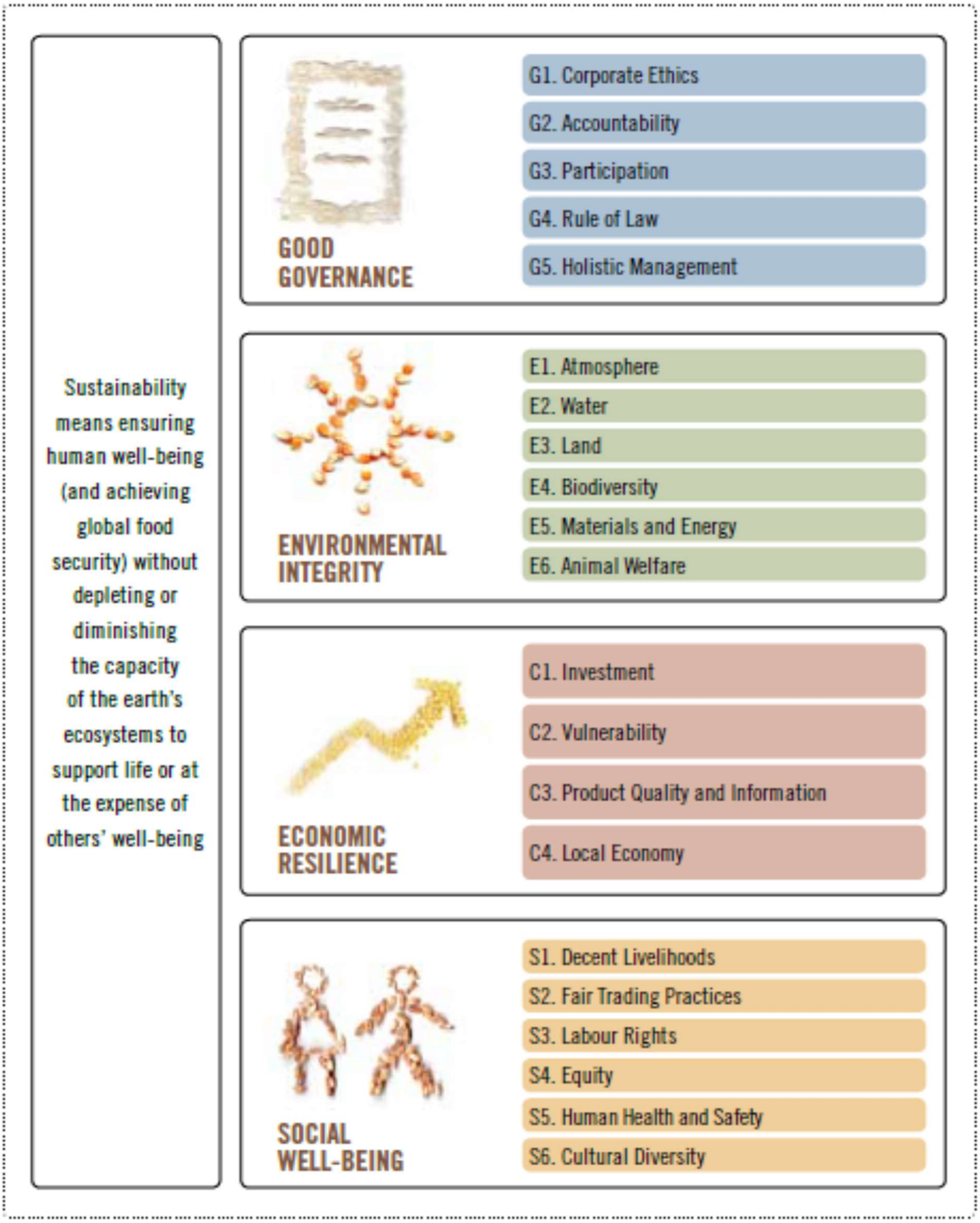

Figure 16 SAFA sustainability dimensions and themes (taken from SAFA Guidelines[2])

A jungle of sustainability claims can be found. The International Trade Centre identified 230 sustainability standards, codes of conduct, protocols[3]. They all have their own, different standards. For agriculture, sustainability tools differ in

- coverage of supply chain links (production, processing and marketing);
- the dimensions and themes covered;
- the scope/purpose of the tool (impact assessment, reporting, certification, etc.).

Sustainability, however, requires a universal framework and thresholds (e.g. sustainable thresholds may differ from legal requirements). Therefore, the FAO developed SAFA[4], an umbrella-like framework for all purposes, with a sustainability threshold. This is multi-purpose framework for governments, businesses (among which farms) and NGOs.

A SAFA exercise starts by defining boundaries. The inclusion or exclusion of upstream or downstream phases along the supply chain does matter in terms of assessment results! Therefore, defining boundaries is crucial.

For each subtheme SAFA offers a 5 scale rating for performance, from "best" (dark green) to "unacceptable" (red). "Unacceptable" or "no go" practices define the bottom threshold for each indicator, usually still above legal requirements. The three middle ratings are defined by users, based on context. It is up to the assessor (company) to decide what the "thresholds" for "good", "moderate" and "limited" are. E.g. for different sectors, different ratings may be applied.

Two tools were developed to implement SAFA.

The SAFA desktop tool (version 2.4.1 in 2018), takes assessors through all steps: setting boundaries, fixing scales for their conditions and choosing indicators. SAFA proposes performance, practice-based and target-based indicators and also own indicators can be introduced. The tool is an open-access and free self-reporting or delegated assessment. The results of the multi-criteria assessment are presented in a radar graph (Figure 17).

As the SAFA tool was found too complex for smallholders, the SAFA App was tailored for them. It is an application for smartphones and tablets, with a one-hour survey, asking up to 100 questions that fulfil 44 indicators for all 21 SAFA themes (instead of 116 Default Indicators of the SAFA Tool). It generates a traffic light coloured histogram, unveiling hotspots across the SAFA themes and showing subordinated evaluation information when a (sub)theme is tapped (Figure 18). Moreover it has the option for advisors to send SMSs and e-mails with recommendations.

SAFA was applied in a variety of settings:

- *Ex-ante* and *ex-post* assessments: impact assessment of projects, assessments of commodity supply chains, evaluations of food security;
- SAFA-inspired tools: sustainable export credentials (e.g. New Zealand Sustainability Dashboard), sustainable business claims (e.g.. SMART-Farm-Tool: see section 3.2.2);
- Policy evaluation: e.g. by the Office of Technology Assessment at the German Bundestag.

Finally, there is a high convergence between the Sustainable Development Goals and the SAFA framework. The SAFA Guidelines have inspired Talukder and Hipel (2016)[5] to propose an approach for constructing a Dashboard that could consider the 169 SDG targets as indicators,

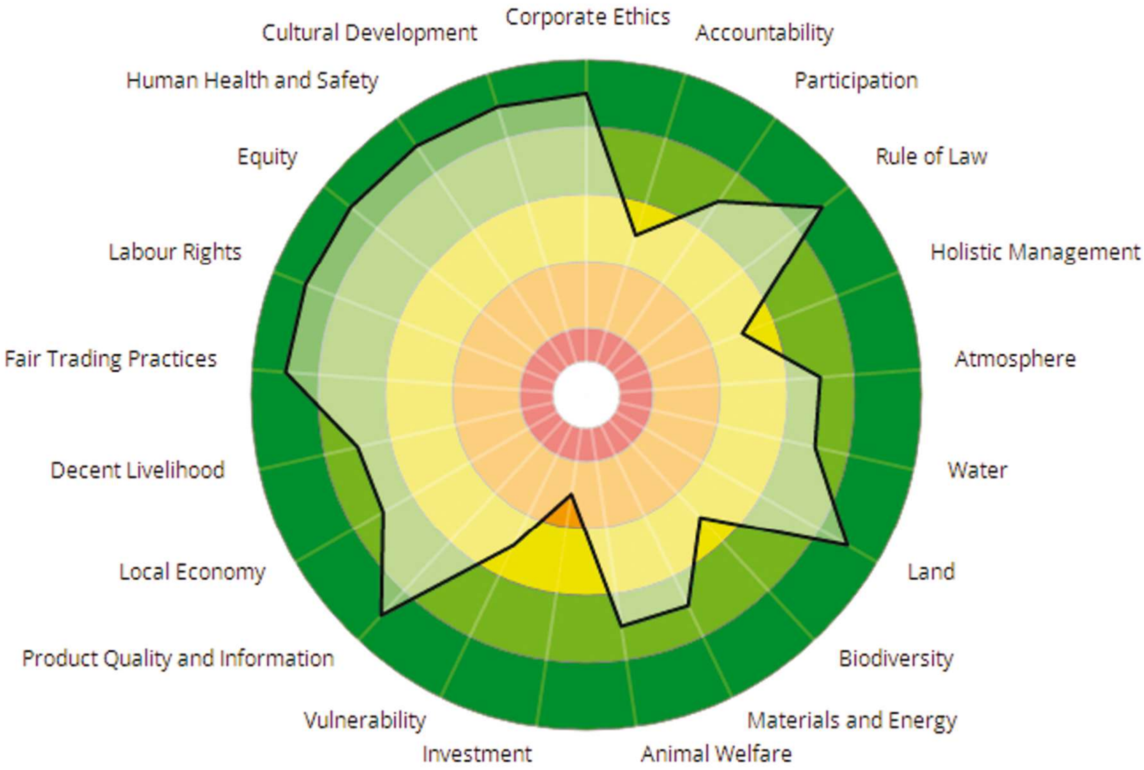

Figure 17 Example of a SAFA performance assessment

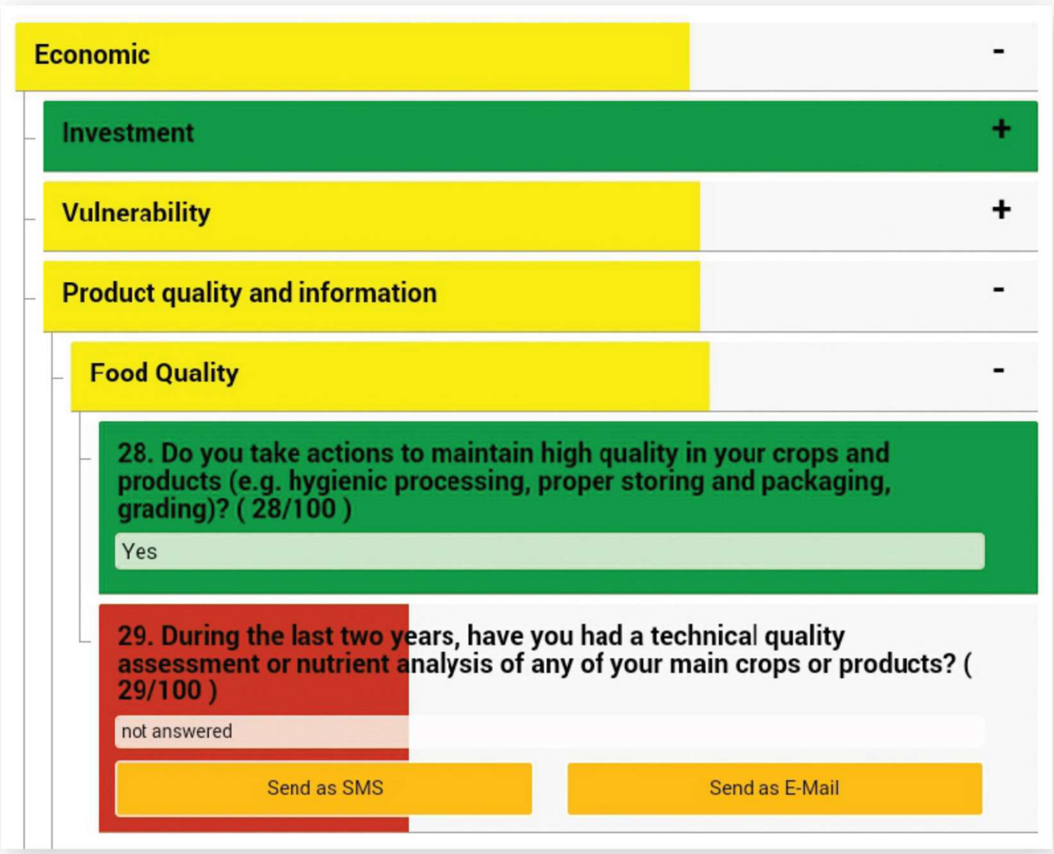

Figure 18 Example of a SAFA App output

3.2.2 Sustainability assessment of agriculture and food systems - Christian Schader (FiBL)

Dr. Christian Schader is leading sustainability assessment activities at the Swiss Research Institute of Organic Agriculture (FiBL). Christian's work encompasses evaluations of environmental, economic and social aspects of food production and consumption. This includes the development and application of methods, models and tools (life cycle assessment, economic-environmental modelling, indicator-based approaches) for analysing different aspects of food supply chains. Christian was also a co-author of the SAFA Guidelines.

Christian's presentation consisted of two parts: (1) defining sustainable agriculture, (2) measuring sustainability.

1. What is sustainable agriculture? What are sustainable food systems?

The planetary boundary concept[6], defines the environmental limits within which humanity can safely operate, based on the intrinsic biophysical processes that regulate the stability of the Earth system (Rockström *et al.*, 2009[7], Steffen *et al.*, 2015[8]). Based upon this concept, three strategies can be related to more sustainable production:

- Efficiency: aims at intensification of production, lowering input/output ratios;
- Consistency: also targets the production process. Its goal is an economic model which is compatible with nature, functioning as a closed loop (circular economy concepts);
- Sufficiency: targets consumption, i.e. reducing the demand for goods and services to a "sufficient" level.

Sustainability assessment approaches, can differ strongly in terms of

- Primary purpose: research, monitoring, etc.;
- Level of assessment: farm level, product/supply chain level, agricultural sector level;
- Dimensions of sustainability covered;
- Geographical scope: applicable globally, to a specific country or region;
- Sector scope: applicable to all agricultural/food products or farm types, to a specific one;
- Perspective on sustainability: farm/business, societal, mixed.
  From the farm perspective, sustainability means "Is the farm working in a sustainable way for surviving in the long term?". From a societal perspective, the question is asked "What does this farm contribute to sustainable development of society?".

(Schader *et al.*, 2014)[9]

2. Sustainability assessment methods for different levels

2.1 Product level: Life Cycle Assessment (LCA)

A LCA model is used to evaluate the environmental impact of a product (e.g. 1 kg of wheat grains at farm gate) through its life cycle, i.e. encompassing extraction and processing of the input materials and the emissions to air, soil and water.

LCA is a very useful method for comparing resource use efficiency at product level or between production systems:

- it relates environmental impacts to the functional unit,
- it takes into account also impacts of input production,
- it is a purely quantitative approach.

But it also has several drawbacks for food and agriculture:

- Only a limited set of environmental impacts can be assessed.
- Many hard assumptions need to be made. This is not problematic as such, but they need to be transparent (which is not always the case).
- The social and economic dimensions are mostly not included.

2.2 Farm or company level: multi-criteria assessment, e.g. SMART-Farm Tool

The Sustainability Monitoring and Assessment Routine (SMART) - Farm Tool operationalises the SAFA Guidelines by defining science-based indicator sets and assessment procedures. It identifies the degree of goal achievement with respect to the 58 SAFA themes, using 327 indicators and 1769 relations between sustainability themes and indicators. The SMART-Farm Tool can be applied to assess the sustainability performance of farms of different types and in different geographic regions[10].

SMART-Farm Tool characteristics:

- Globally applicable, producing comparable results;
- Method independent and science-based;
- On-farm data collection is done by an independent auditor;
- Useful for a large-scale benchmarking and monitoring;
- Coverage of most important drivers for sustainability, drivers being made transparent;
- Expert-based weighting of indicators and (sub)themes.
- Synergies and trade-offs between sustainability dimensions are evidenced

The SMART-Farm Tool can be used for comparing production systems (e.g. Figure 19) or standards.

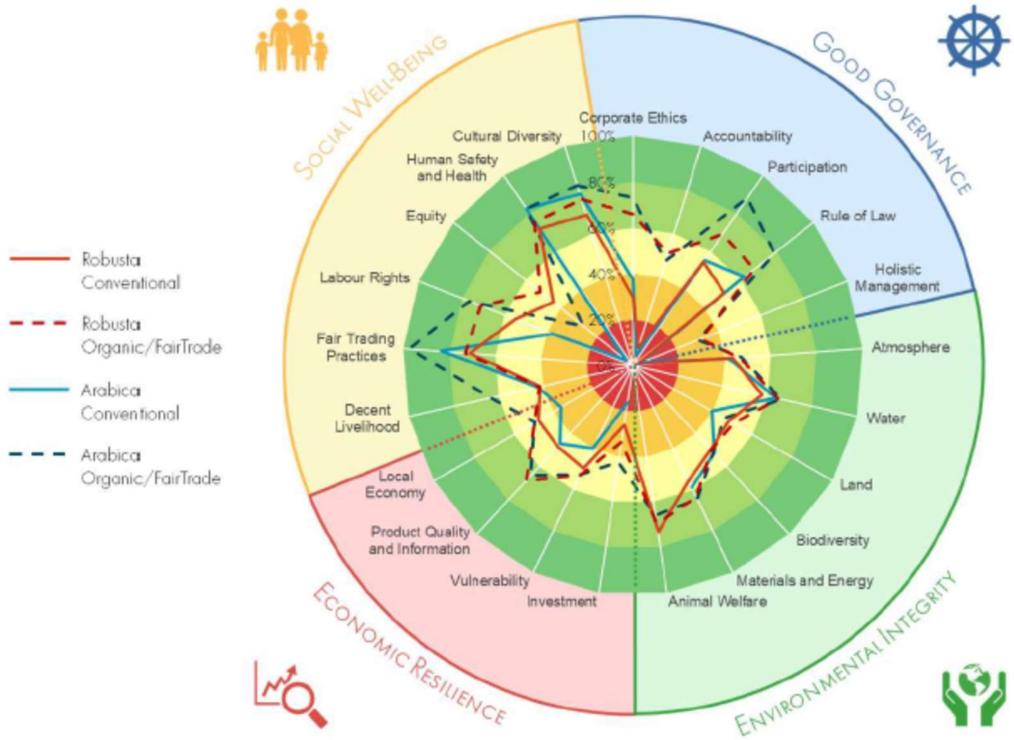

Figure 19: Comparison of conventional, Fair Trade and organic coffee production with the SMART-Farm Tool (Ssebunya et al., 2019[11])

2.3 Sector level: Economic and mass flow models

The results of some research that used economic-environmental models was shown:

- Comparison of average global warming potential in different regions per ton milk delivered by dairy cattle.
- Impacts of feeding less food-competing feedstuffs to livestock on global food system sustainability (Schader *et al.*, 2015[12]). This research assumed that arable land would only be used for food production (not feed) and took the sufficiency principle for human diets into account.

3.2.3 Novelties in Life Cycle Assessment – Veerle Van linden (ILVO)

dr. Veerle Van linden is a senior researcher at the Flanders research institute for agriculture, fisheries and food (ILVO). She uses LCA to evaluate agricultural production processes for their environmental impact. She does this in a food chain perspective. Moreover, she looks beyond the greenhouse gas emissions, in order to avoid shifting the problem. Therefore, she among others, led research on incorporating the soil into LCA.

Veerle started by reminding us of what LCA is: modelling direct plus indirect emissions and resource use of a certain product. For agricultural products, the analysis stops at the farm gate (Figure 20). As Christian already mentioned, it is very important to make explicit what exactly is taken into account in the analysis. LCA is more than carbon footprinting, which is only one impact category. Impact categories that can be taken into account in LCA include climate change, eutrophication (marine, fresh water, terrestrial), acidification, particulate matter formation, ozone depletion, human toxicity, land occupation (agricultural, urban), and fossil depletion.

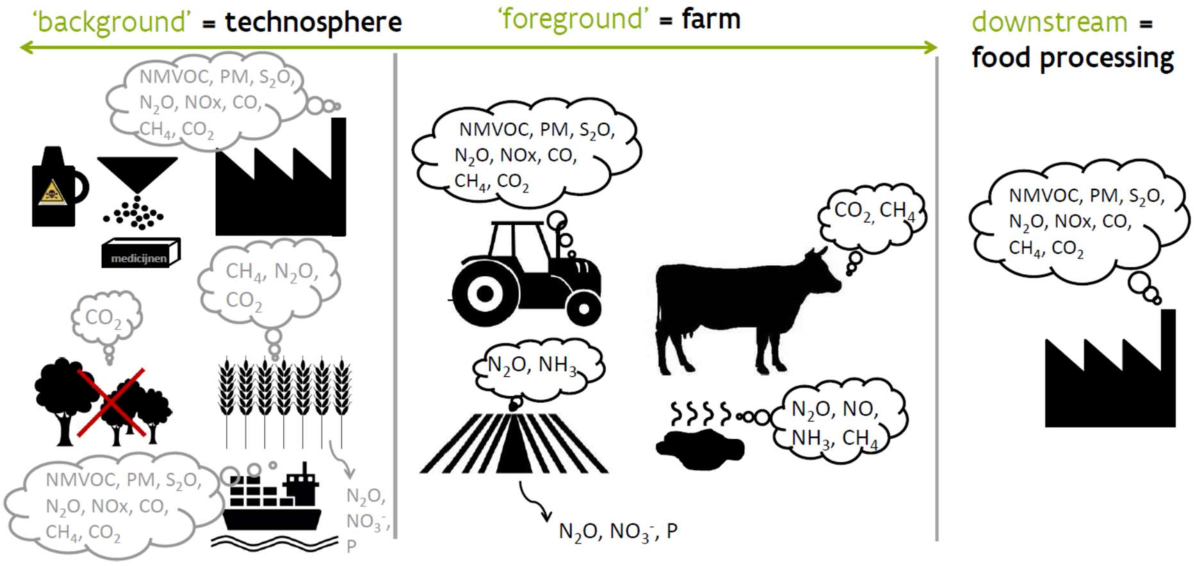

Figure 20: Boundaries of farm level LCA and emissions taken into account

To evaluate the resource efficiency of agricultural systems the **exergy** concept is used by ILVO. The exergy concept, which originates from the second law of thermodynamics, is stated to be an appropriate quantifier for both the amount and quality of material and energy flows in one common unit, i.e. joules of exergy. According to the second law, every process transforms resources into work, heat, and/or products, by-products and wastes, and generates entropy. The sum of the exergy embodied in these outputs is lower than the input of exergy in the resources, because part of the initial exergy is dissipated through irreversible entropy production. The quality of resources thus decreases in every transformation step. An exergy analysis of dairy farming showed that more than half of the resources consumed by the farm's herd was irreversibly lost. The remaining went for almost two-thirds to manure (54%) and methane emissions (9%), while only one-third flowed to end-products, i.e. milk (32%) and the animals awaiting slaughter (2%). The ELCA identified the feed supply as the most demanding part of the dairy production chain by far, representing 93% of the resource footprint. Overall, concentrates were on average 2.5 times more resource-intensive per kg dry matter than roughages (Huysveld et al., 2015)[13].

Challenges to conduct LCA in the agricultural sector tackled at ILVO:

- Variability of input data,
- Long term productivity,
- Ecosystem services.

An analysis of factors causing variability in grain maize production showed that policy, farm management, year-to-year weather variation and innovation could all drive variability. For example, farm management choices such as fertiliser type have a large effect on emission-related problems (e.g. eutrophication and acidification). Innovation caused the largest improvement of environmental performance, as plant breeding resulted in a steadily increasing yield (Boone et al., 2016[14]).

Worldwide, soil organic carbon (SOC) decline is considered as a main danger which affects long term soil fertility and productivity. A new indicator was introduced, which allows to make a trade-off between continuing the same agricultural management practices that lead to SOC depletion or investing in better soil quality by addition of soil organic carbon. This framework was constructed from a resource point of view. A case study in Flanders compared different remediation strategies. In general, the high benefits were shown to offset the effort to remediate SOC levels (Boone et al, 2018a[15] and b[16]).

To better account for ecosystem services (ES) in LCA an allocation procedure was proposed. It is based on the capacity of agricultural systems to deliver ES and divides the environmental impact over all agricultural outputs (i.e. provisioning and other ES). Allocation factors were developed for conventional and organic arable farming systems. Applying them, it was demonstrated that for about half of the food products (including maize, potato), organic farming has clear environmental benefits in comparison to conventional cultivation methods (Boone et al., 2019[17]).

Finally, the new Klimrek project offers climate scans to farmers. An LCA based scan of the farm shows which measures could most effectively mitigate the farm's greenhouse gas emissions. In addition, a cost/benefit analysis of the measures is made, to inform the farmer about the measures best suited for his/her farm. An advisor accompanies and facilitates the on-farm implementation.

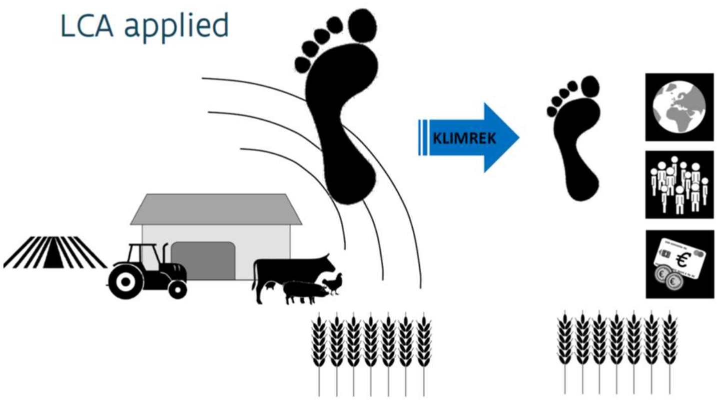

Figure 21: LCA application in the Klimrek project

3.2.4 Use of sustainability assessment to help in the design of innovative cropping systems: examples with MASC and DEXiPM models – Frédérique Angevin (INRA)

Dr. Frédérique Angevin is a senior researcher at INRA (Eco-Innov Unit, France). She is an agronomist, with a PhD in environmental sciences. Her research aims to facilitate the design of innovative cropping systems (e.g. less pesticide-dependent or less energy-intensive) while preserving their economic viability and acceptability. To this end, she participates in the design of tools (multi-criteria models) for assessing the economic, societal and environmental performances of innovative systems that take into account the sometimes divergent preferences of the different actors. She also used to work as a farmer advisor, which explains her interest in the transfer of research results and approaches that include stakeholders.

The MASC model is a **multi-attribute assessment** of the sustainability of cropping systems. Based on the growing number of challenges in agriculture, the pedo-climatic and socioeconomic context, and the different perceptions about the performances reached (consumer vs. farmer preferences), there is a need for a sustainability assessment method that is able to handle:

- a wider range of knowledge via the use of **qualitative information;**
- a larger diversity of contexts and of decision-makers;
- operational scales for farmers, such as the cropping system (CS) level (CS being the sequence of crops at the field scale + the management of each crop).

MASC is implemented within DEXi computer software (Bohanec, 2014[18]). It's first version was published in 2009 (Sadok et al., 2009[19]). Version 2.0 incorporated adaptations according to end-user feedbacks (Craheix et al., 2012[20]).

In MASC, the assessment problem is structured and broken down the into sub-problems.

- Each dimension is split up into a set of "basic criteria" (e.g. profitability, NO_3 losses);
- It consists of a decision tree, in which all criteria are qualitative (e.g. low, medium, high);
- This information is then aggregated towards overall sustainability through Utility Functions. The weights of the (sub)themes used in the aggregation can be adjusted by the users depending upon their specific context or their specific perception of sustainability. E.g. if there is a problem in terms of erosion, it can be indicated as (more) important.

Different types of outputs can be generated by the software:

- Bar charts comparing results for 1 assessment criterion obtained under different scenarios;
- Two-dimensional graphs combine the results of 2 evaluation criteria;
- Radar graphs showing results for the 3 dimensions of sustainability or for all the themes within a dimension;
- A dashboard showing a global overview of the evaluation results, with colours from dark green (very high) to red (very low) indicating the scores (Figure 23).

MASC can be used for sustainability assessment

- *Ex post*, to assess existing cropping systems,
    - to identify the weak/strong points of technical strategies and rotations,
    - to help in monitoring of trials and interpretation of results in long term experiments,
    - to help in adaptation of systems in step by step design with farmers.
- *Ex ante*, to assess alternative solutions
    - to help in the design of promising systems before field testing, while having an overview of synergies and trade-offs in innovative systems.

An example of this *ex ante* use was in the Sysclim project (Craheix et al., 2014[21]), in which innovative systems to mitigate climate change and to meet sustainable requirements were designed with farmers. A participatory approach was used, considering the farmers' expectations, according to the do-check-adjust-act cycle (Figure 24). MASK was used in the CHECK-step to assess the current CSs. In the ACT-Step, results were collectively analyzed in a workshop with farmers in order to identify a shared pathway to improve current systems. MASC was again used to analyse the potential new CS in-depth.

The DEXiPM model, was also designed for the *ex ante* assessment of innovative CS on a similar canvas and with a similar structure. Versions are available for arable crops, pome fruits, field vegetables and grapevine. It overcomes the lack of data on innovative systems using qualitative estimation from expertise (Pelzer et al., 2012[22]; Angevin et al., 2017[23]).

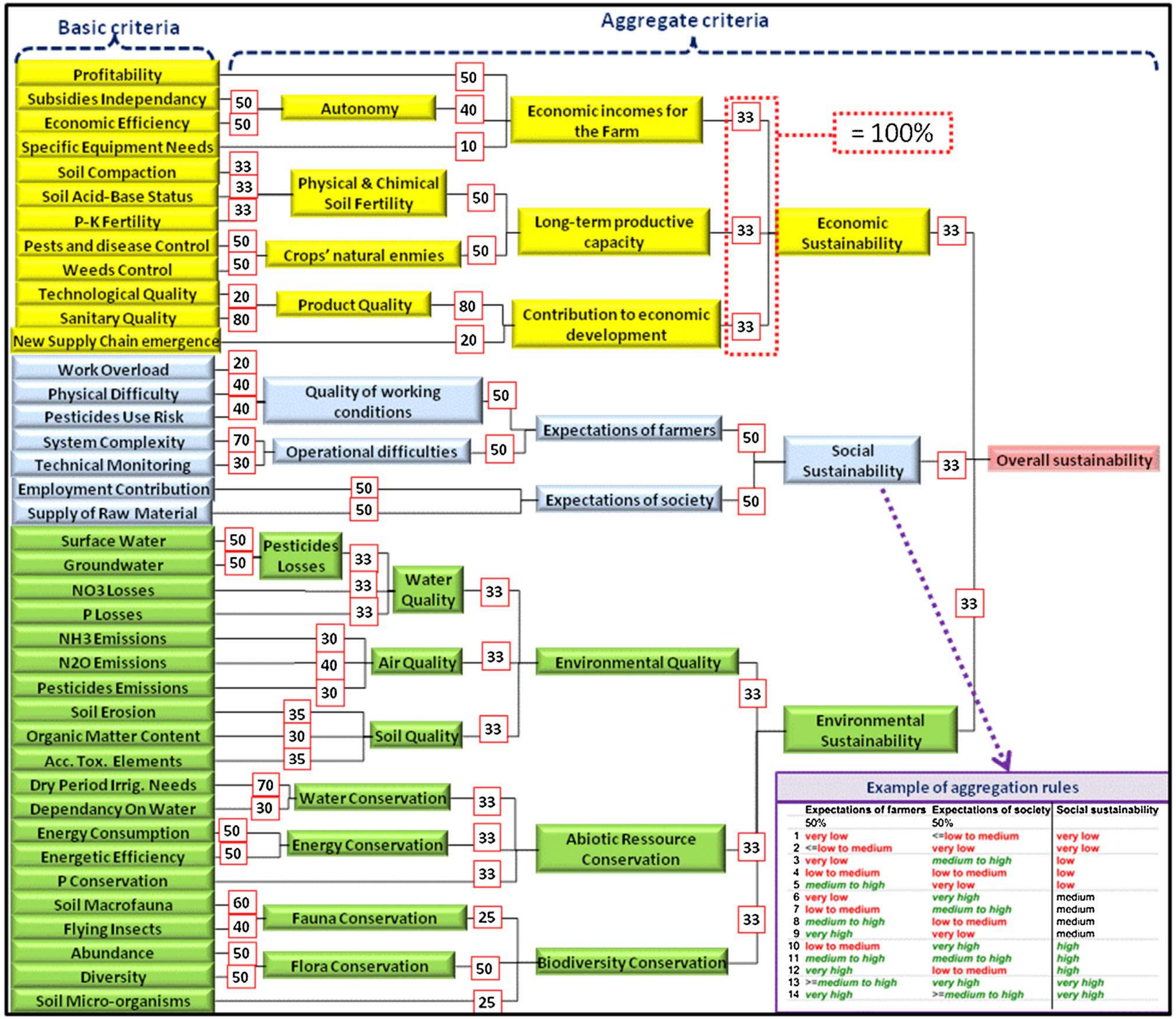

Figure 22: Sustainability criteria evaluated in MASC and aggregation into subthemes and themes. Numerical values in the decision tree displayed in red boxes represent the weights (expressed in %) proposed by the designers of the MASC model (taken from Craheix et al., 2016[24])

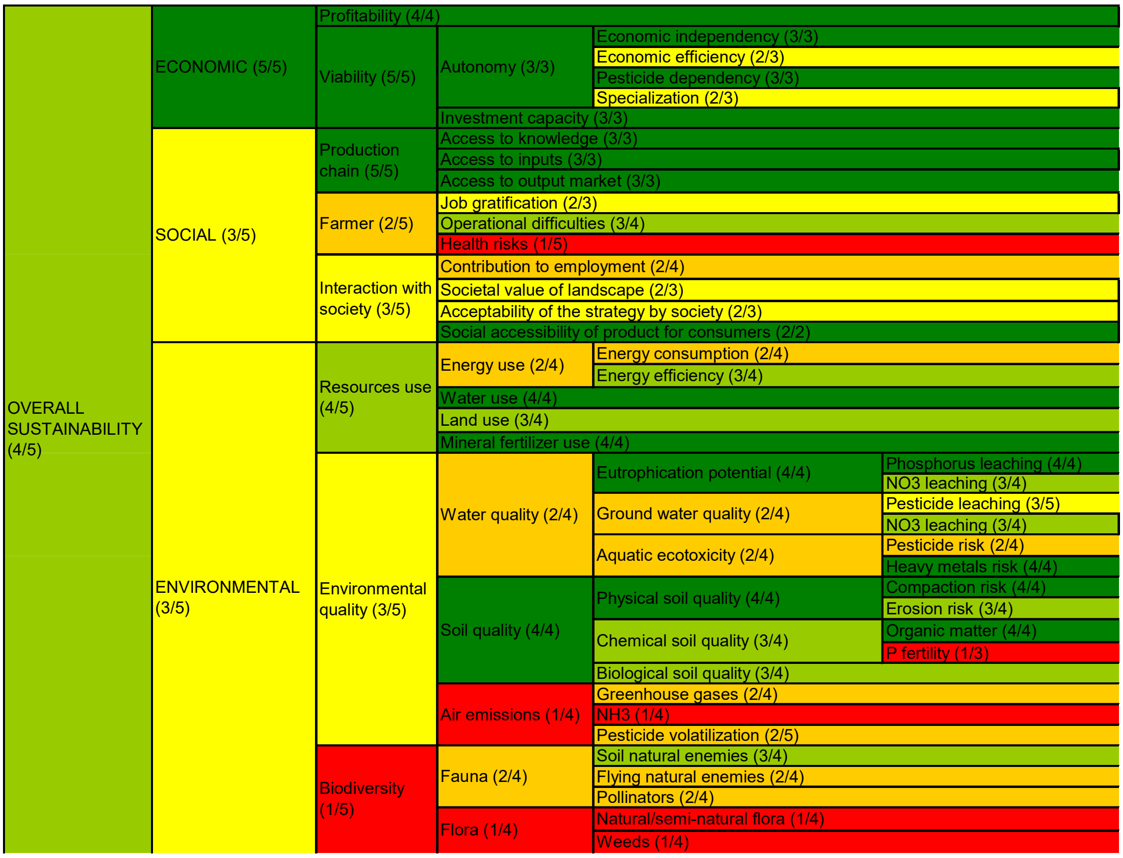

Figure 23: An example of a dashboard output from the MASK model

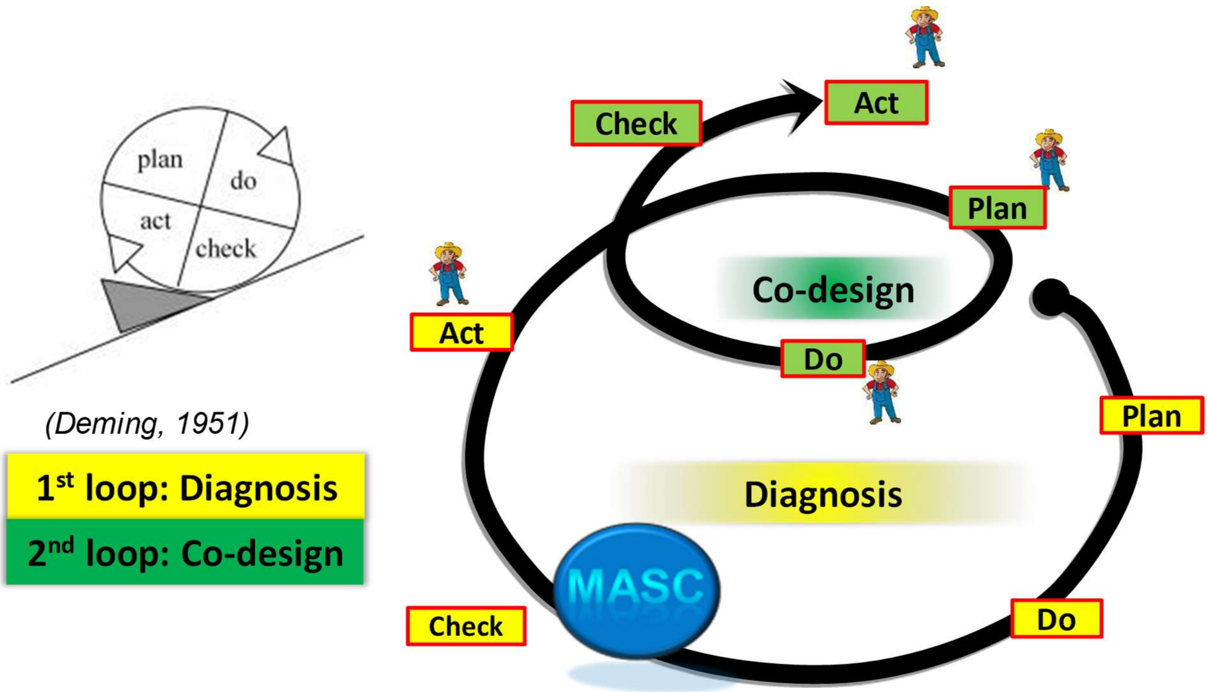

Figure 24: Diagnosis and co-design cycle implemented to design innovative cropping systems to mitigate climate change (taken from Craheix et al., 2014).

3.2.5 How do current sustainability assessment tools support farmers' strategic decision making? – Ine Coteur (ILVO – KULeuven)

Dr. Ine Coteur did her PhD at ILVO and Ghent University on the role of assessment tools in the agri-food system, with special attention to farm management. Now she is coordinating sustainable development at the university in Leuven.

A transition is needed from the current farming system to a more sustainable system. Previous speakers have already shown that sustainability assessment tools (SATs) can help farmers to make decisions: structuring complexity, seeing the broad picture, they can initiate a learning process. However, using the right tool is crucial. A tool that matches the goals of a farmer, the context in which the farmer runs the farm and his/her view on sustainability at that moment. This is not easy given the myriad of existing SATs (already mentioned by Nadia).

The multitude of farm level sustainability assessment tools (SATs) reflects the complexity of agricultural practices and the variety of sustainability perceptions. However, insights regarding the farmer's choice between the myriad of SATs and their potential use are lacking. It was examined if and how existing SATs focus on the strategic decision-making of the farmer as their end-user. The potential to direct farmers towards more sustainable management was explored by focusing on the implementation and decision-making process rather than solely on the SAT content. Based on interviews with the tool developers and the published SAT characteristics, 18 known SATs were classified in a two-dimensional framework. One axis reflects the overall complexity of the SATs, i.e. time required for the entire assessment process, type of assessment and of the indicators applied, and thematic coverage. The other axis reflects the steps in the farmer's strategic decision making process, i.e. assessment, interpretation, development of improvement strategies, their implementation, and monitoring of results (Figure 25).

Examples of tool classification:

- Level 1: LEAF-SFR is a mainly qualitative on-line self-assessment, using target- and practice-based indicators that can be done in 2-4 h. The self-assessment has links to guidance and signposting to extra material that explains the meaning of the question. Results are presented in a report without further support. Also the SAFA App was classified here.
- Level 2: RISE is more complex assessment that is done by an advisor. It uses both qualitative and quantitative data and a combination of practice-, performance- and target-based indicators. Data collection takes 3-5 h and the total assessment 5-9 h. Results are presented in a detailed report. There is a feedback discussion between farmer and advisor and advice is included to develop improvement strategies. Also the SMART-Farm tool was classified at this level, but it includes less steps in strategic decision making.
- Level 3: Ben & Jerry's Caring Dairy Program (BJCD) is a certification scheme with focus on the individual farmers' learning and improvement trajectory. Each farmer yearly needs to attend at least 3 workshops with peers. Expert Improvement strategies are developed and implementation is discussed during farm visits and workshops. Yearly monitoring is compulsory for certification.

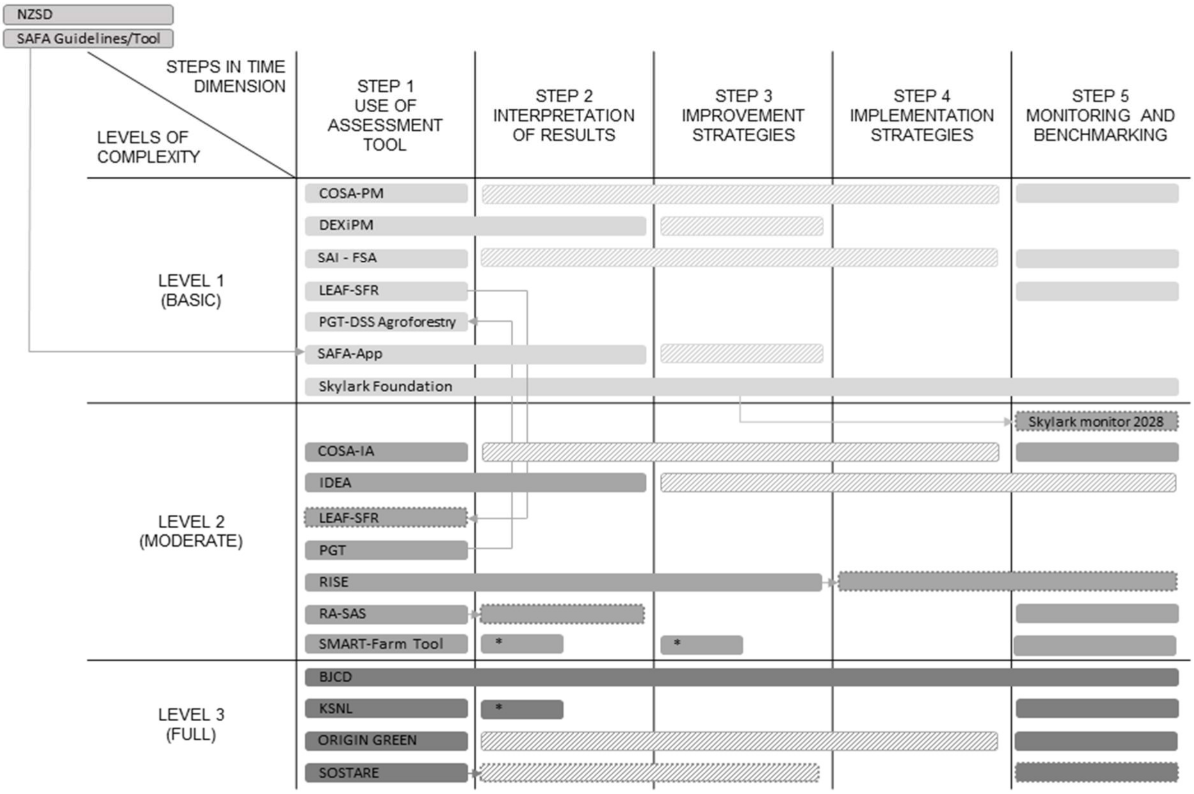

*Figure 25: Overview of SATs classified according to their complexity level and the steps in farmers' strategic decision making (coloured bars = position of SAT in time-complexity framework; dotted bars = the future ambitions of the SAT developers, indicating the direction in which they want these tools to evolve; hatched bars = steps dependent on external parties; * = only non-personal information via report) (taken from Coteur et al., 2020[25]).*

We made three main **observations**: (1) Many SATs lack a focus on the implementation of the assessments' results and thus provide only a weak link to the farmers' strategic decision making; (2) over time, a SAT's complexity may evolve, causing it to shift to another complexity level; (3) a diversity of goals was found at each level of complexity. These observations allow us to conclude that SATs are gradually becoming more farm or farmer focused, offering more context specificity and flexibility. The farm(er) focus and the support for strategic decision-making play a central role in the adoption of sustainable practices if there is sufficient interaction between farmers, advisors and experts. Future research should therefore focus on integrating support for farmers' strategic decision-making in (further) development of SATs and in their implementation process.

Recommendations for SusCrop:

1. Focus on the implementation process of the SAT results. Even if the tool you are using does not focus on the implementation process, you can organize discussion groups or field visits to support the implementation of improvement strategies and possibly initiate a learning process. Generate actionable knowledge.
2. Choose a tool that fits the context of a farm, a tool that will help achieve the goals of the farmer at that specific moment in time.
3. Embed regular reflection moments to evaluate the value of using a specific assessment tool, to evaluate the changing context in which the farmers operate and to engage with the farmers using the SAT and implementing the improvement strategies.

3.2.6 EIP-AGRI work on farm sustainability issues - Sergiu Didicescu

Sergiu Didicescu is a Farm Practice Officer at the EIP-AGRI Service Point of the European Innovation Partnership for Agriculture. He aims at bridging the gap between science and practice in the European agri-food sector by mapping and linking innovative projects in the agri-food sector, stimulating participation of farmers and food makers in the EIP-AGRI network, and bringing researchers closer to practical needs of day to day farming

Recalling the EIP-AGRI workshop on "Tools for environmental farm performance", organised in 2017 to discuss the uptake and ways to increase the uptake of sustainability tools, Sergiu reminded us about some of the most important conclusions[26]:

- There is no one-fits-all tool. Each group, process, farmer group has to choose a tool according to the stated goal. The purpose of the tool should be related to the incentives of end-users.
- Ideally, farmers are implied in the choice (and even formulation) of the sustainability indicators
- On the level of the assessment, a farmer needs his own farm-specific trajectory connecting the right tool to the time frame of strategic process on the farm. Farmer expectations about a SAT are represented in Figure 26.

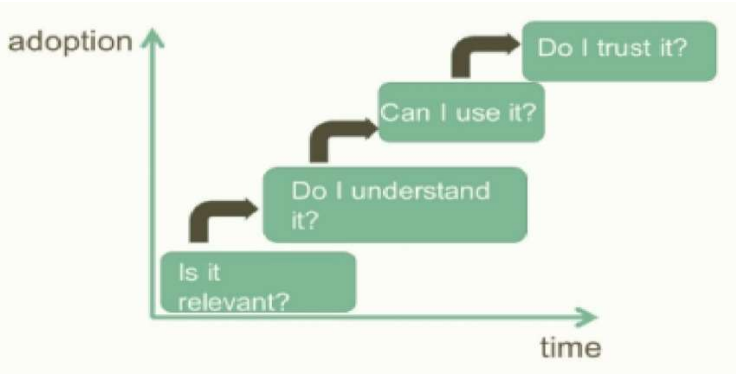

Figure 26 Farmers' expectations about sustainability tools

Efficient SATs are:

- Effective, i.e. stimulates improved farm management;
- Affordable in the context in which it is expected to be used;
- Sufficiently specific to meet users' expectations;
- Flexible, i.e. capable of adjusting to different farm types/sizes;
- Simple to understand and not dependent on a lot of complex or time-consuming data input;
- Trustworthy, i.e. producing reliable results;
- Accessible and attractive.

Sergiu mentioned Skylark[27] ("Veldleeuwerik") as a good example. This is a Dutch knowledge platform where arable farmers collaborate with partners from the supply chain to achieve a more sustainable agriculture. Farmers participate voluntarily, they make a sustainability plan for their farm with an accredited advisor, regional groups of 10-12 farmers meet regularly to discuss progress.

3.3 Discussions on sustainability assessment

The plenary presentations were followed by two discussion groups, one on Life Cycle Assessment and one on Multi Criteria Assessment at farm level.

3.3.1 Life Cycle Assessment

Experts: Christian Schader, Veerle Van Linden

Some issues raised in this discussion:

- When to use LCA? It is a good approach to compare the environmental burden of food/feed/product production taking into account upstream, production and downstream aspects. Or to compare technical processes for example. If you want to assess impact on the environment and the impact is quantifiable, LCA is a good choice. If data are lacking, then other, more qualitative approaches are more appropriate.
- Where to get data? Several extensive databases are available providing the footprint of e.g. 1 kg wheat or 1 kg beef meat etc. Examples are ecoinvent[28], Agri-footprint[29], USEtox[30], FeedPrint[31]. Data can also be found with the Intergovernmental Panel on Climate Change (IPCC)[32]. SimaPro[33] is a Life Cycle Assessment (LCA) software. If data are not available, estimates can be used.
- There are two methods: (i) Attributional LCAs seek to establish (or attribute) the burdens associated with the production and use of a product. In 90% of the cases, these attributed burdens are used. (ii) Consequential LCA seeks to identify the environmental consequences of a decision or a proposed change in a system, answering the question "What if…". E.g. "What if a kg of carrot were produced according in an organic system?"
- Be aware that socio-economic factors are not taken into account; soil quality and C-sequestration are also not taken in account (in general).
- Because an LCA does not take certain aspects in account, it is advised to make use of more than one sustainability assessment and to combine complementary ones (also to capture quantitative and qualitative issues).

Figure 27: Discussion group on Life Cycle Assessment (Photograph: Nikki De Clercq, ILVO)

3.3.2 Multi Criteria Assessment at farm level

Experts: Nadia El-Hage Scialabba, Frédérique Angevin, Ine Coteur, Sergiu Didicescu

Some issues raised in this discussion:

- Effectiveness: 2 schools: (1) interventions by policy makers, (2) markets
  Drivers for farmers: motivators to use tools can be additional added value (unique selling point), business development, …
- Involvement of farmers in the process:
  - Differences between sectors in expectations
  - Difficult: they may not experience the need for change
  - Important role for advisors
- Platform for tool choice for advisors / farmers: would this be useful?
  - Should give and overview of different tools
  - Should state the goals of the tools etc.

  Aim = facilitate selection of tools in e.g. a project.
  This would need a huge workload!
  Existing platforms: National: e.g. Erytage[34] in France
  Sustainability Standards[35], by the International Trade Centre for certification schemes
- Tools should be flexible to deal with new evolutions, to incorporate new scientific knowledge, changing priorities, etc.
- How to benchmark? Possibilities are
  - Discussion groups (farmers challenging each other)
  - Expert knowledge of advisors visiting the farm
  - Databases, e.g. Farm Accountancy Data Network (FADN)[36] for economic and some environmental issues, regional/national environmental monitoring e.g. by the European Environment Agency[37]
- Tools for the whole supply chain? For example the SAFA tool
- How to involve farmers in the discussions?
  - Participatory methods
  - Share recommendations, trigger interest

Figure 28: Discussion group on Multi Criteria Assessment (Photograph: Nikki De Clercq, ILVO)

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