TempAg Pilot Activity 1.1.1

Survey of Sustainability Assessment Methods

ILVO
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Theme 1: Delivering Resilient Agricultural Production Systems at Multiple Levels

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Content

1 Introduction 1

2 Inventory of sustainability frameworks, metrics & tools 2

2.1 Inventory compilation 2

2.2 Selection of frameworks, metrics & tools 3

3 Characteristics for assessment system description 4

3.1 Characteristics of assessment systems found in literature 4

3.2 Selection of the characteristics to be surveyed 11

4 Analysis of assessment characteristics 14

4.1 Descriptive analysis 14

4.1.1 General assessment characteristics 14

4.1.2 Stakeholder participation 24

4.1.3 Indicator related information 27

4.2 Relations between the general assessment characteristics 33

4.2.1 Correlations between the assessment characteristics 33

4.2.2 Associations between the categorical variables 35

4.2.3 Stakeholder participation in relation to other assessment characteristics 42

4.3 Cluster analysis 48

5 Preliminary conclusion 49

Appendix 1: Inventory of sustainability frameworks, metrics and tools 53

Appendix 2: Survey of sustainability frameworks, metrics and tools 77

1 INTRODUCTION

The TempAg research collaboration on sustainable temperate agriculture aims to deliver resilient agricultural production systems at multiple levels. Within this overarching scientific goal, three research themes have been defined:

Theme 1	Delivering Resilient Agricultural Production Systems at Multiple Spatial and Temporal Levels
Theme 2	Optimising Land Management to Produce Food and Other Ecosystem Services at Landscape Level
Theme 3	Sustainably Improving Food Productivity at Farm/Enterprise Level

Here we rep ort on the first pilot activity within the first theme.

The research question posed for Activity 1.1 originally was *"How can conceptual frameworks be developed for defining agricultural sustainability at multiple levels?"*. After input from the network kick-off meeting on April 22nd, 2015, at the National Institute of Agricultural Research (INRA) in France, this research question was rephrased as *"How can sustainability frameworks, metrics and tools and their implementation be enhanced to futureproof agricultural decision making at multiple levels on multiple scales?"*.

For what is "sustainable agriculture"? How is it perceived in different regions and in different contexts? How can agriculture's sustainability be assessed? In trying to answer those questions, a myriad of frameworks, metrics and tools have been developed over the past two decades. Assessments originated top-down or bottom-up; with or without the involvement of stakeholders; aiming at farm development, food certification, policy evaluation, global reporting, etc. The first step in unravelling the question how all these frameworks, metrics and tools and their implementation may be enhanced to futureproof agricultural decision making consisted in getting a grip on what is currently being used, how it came into being and how different purposes resulted in different assessment methods. The task for Pilot Activity 1.1.1 thus was *to survey on-going and recent work for assessing sustainability in temperate (non-tropical) countries*.

This report describes Pilot Activity 1.1.1 and its results. The next chapter describes the inventory of sustainability frameworks, metrics and tools that was made, and how a selection was made within the inventory to be surveyed with the developers and/or users. Chapter 3 discusses the characteristics that were used to describe the sustainability frameworks, metrics and tools, i.e. which characteristics were found in literature and which ones were selected for the survey questionnaire. Chapter 4 shows the survey results: general assessment characteristics reported by the respondents, stakeholder participation during development and implementation, and information related to the indicators used in the assessments. Finally we try to establish how this information can help to unravel the question how sustainability frameworks, metrics and tools and their implementation can be enhanced to futureproof agricultural decision making at multiple levels and multiple scales.

2 Inventory of sustainability frameworks, metrics & tools

Pilot Activity 1.1.1 started by making an inventory of sustainability frameworks, metrics and tools. Subsequently a selection was made within this inventory, searching for those assessment systems that used a broad definition of sustainability and seemed most appropriate to enhance agricultural decision making.

2.1 Inventory compilation

Fifteen years ago already, Riley (2001) noticed an “explosion” of indicators for agroecosystems, sustainable land management, biodiversity, social development, rural livelihoods, conservation of natural resources, etc. Nowadays many of those indicators are used in more holistic frameworks, encompassing several or all of the aspects mentioned. However, the universe of frameworks, metrics and tools for agricultural sustainability assessment is ever-expanding (Pope *et al*., 2013; Schindler, 2015). Any effort attempting an inventory of assessments can therefore at best be comprehensive, but not exhaustive.

Pilot Activity 1.1.1 could elaborate on several earlier compilations of frameworks, metrics and tools. For example the FAO, in their Sustainability Assessment of Food and Agriculture (SAFA) framework gave an overview of the landscape of sustainability initiatives. Therein 38 initiatives were categorised according to their scope (policy planning, reporting by organisations, benchmarks for setting standards, standards for products, assessments of the performance of production units or supply chains) and their place in the supply chain (inputs, production, processing, manufacturing, packaging, distribution, retail, consumption) (FAO, 2013).

An overview was also made by the TempAg network. It listed 76 frameworks, metrics and tools, which were characterised according to their specificity for agriculture; their origin; their scope (in the sense of the sustainability dimensions assessed); key drivers (policy, market assurance, business improvement); and spatial scale (farm, industry, regional, national, international).

Over the past years an inventory of tools was already made at the Institute for Agricultural and Fisheries research (ILVO). This inventory categorised tools by the sustainability dimensions considered, the intended end user, the data sources, the method of data gathering and the time needed for data collection, the type of aggregation, and the spatial scale of the assessment. Moreover, this inventory focussed on the indicators used in different assessment systems (a sample of this inventory is shown by Marchand *et al*., 2014).

In Pilot Activity 1.1.1 the different existing inventories were combined and complemented by means of a study of peer reviewed, grey literature and internet sources. We thus compiled an inventory that currently contains 170 sustainability frameworks, metrics and tools. An overview of this inventory, with the assessments’ code, full name, initiative, origin, scope and sources, is given in Appendix 1.

2.2 Selection of frameworks, metrics & tools

The inventory is too broad to study all assessment systems in detail. Therefore a first selection was made, keeping in mind that the *sustainability* frameworks, metrics and tools need to be able to futureproof *agricultural* decision making in *temperate* countries *at multiple levels on multiple scales.* The first selection was thus based on some fundamental characteristics that were derived directly from the research question. Frameworks, metrics and tools were selected for further evaluation, if they were:

- *Specific to agriculture* or applicable to agriculture with minor modifications;
- Developed in and/or applicable in *temperate* climates;
- Designed to assess *sustainability*. As sustainability is commonly seen to encompass at least three dimensions, economic, environmental and social sustainability (WCED, 1987; Hardi and Zdan, 1997; Kates *et al*., 2005 Strange and Bayley, 2008; Hurni and Osman-Elasha, 2009; FAO, 2013; Schindler *et al*., 2015), frameworks, metrics and tools were selected as much as possible to assess at least those three dimensions;
- Assessment systems were not specifically selected on their *scope*, nor on the *level* or *scale* at which the assessment is made, although emphasis was put somewhat more on farm level assessments.

The sources on all 170 sustainability frameworks, metrics and tools (literature and websites), at hand at the time, were scanned for these basic characteristics and they were added to the inventory, as given in Appendix 1. The selection revealed 53 frameworks, metrics and tools that comply with the basic characteristics. The selection contains systems from temperate climates all over the world, with broad ranges of scopes, assessment levels and data gathering scales.

A questionnaire was then developed to systematically survey further essential characteristics of the selected frameworks, metrics and tools. The next chapter describes how these essential characteristics were selected.

3 CHARACTERISTICS FOR ASSESSMENT SYSTEM DESCRIPTION

How does one navigate between the myriad of sustainability assessments? How can one find the way to the right tool for one's purpose? Are there any dots and lines to make up a map? In other words: What are the key characteristics to describe frameworks, metrics and tools that may facilitate choice? This chapter first gives an overview of the characteristics found in literature and then describes our selection of characteristics.

3.1 Characteristics of assessment systems found in literature

Booysen (2002) presented a framework for distinguishing between different types of macro-level development indicators. As a motivation, he invokes Drewnowski (1972), who claimed that one requires some "ordering principles for the selection of useful indicators and rejection of ill-conceived and inapplicable ones", a goal still valid today, if one takes into account that different indicators, frameworks, metrics or tools will be "useful" or "applicable" in different situations. Table 1 shows Booysen's characteristics for classifying and evaluating development indicators.

Table 1. Characteristics for classifying and evaluating development indicators (Booysen, 2002)

Characteristic	Description
Content	What aspects or facets of development does the indicator measure?
Technique and method	Does the indicator measure development in a quantitative (qualitative), objective (subjective), cardinal (ordinal), or uni-dimensional (multi-dimensional) manner?
Comparative application	Does the indicator compare the level of development (a) across space ('cross-section') or time ('time-series'), and (b) in an absolute or relative manner?
Focus	Does the indicator measure development in terms of input ('means') or output ('ends')?
Clarity and simplicity	How clear and simple is the indicator in its content, purpose, method, comparative application and focus?
Availability	How readily available are data on the particular indicator across time and space?
Flexibility	How relatively flexible is the indicator in allowing for changes in content, purpose, method, comparative application and focus?

Also in 2002 van der Werf and Petit evaluated indicator-based assessment methods for environmental impacts and at the farm level. They aimed "to propose a set of guidelines for the evaluation or development of such methods" and "to provide a characterisation of the methods' components and functioning at the farm level".
Three years later Payraudeau and van der Werf (2005) took their review of environmental impact assessments to the regional level. As before, the objective was "to extract the key elements which enable one to choose or develop a method of environmental impact assessment for a given farming region". The characteristics used in both studies differ only slightly and are integrated in Table 2.

The key elements listed in both studies are summarised here (for a complete list we refer to the original publications):

- The inclusion of *economic* and *social* objectives can balance the *environmental* value of new farming practices against their social and economic viability.
- The number of objectives should be *sufficiently large* to avoid the inadvertent creation of new problems, and as small as possible to maintain *feasibility*.
- Methods using *effect-based indicators* are preferable as the link with the objective is more direct and the choice of means or practices is left to the decision maker. *Means-based*

indicators cost less in data collection but do not allow an actual evaluation of environmental impact. Validation of effect-based indicators is easier (Figure 1).

- The temporal and spatial scales of analysis should compromise between *precision* and *practicability* of the method.
- Methods which allow the expression of impacts according to several reference units are preferable, as they allow the different functions of agriculture to be evaluated, e.g. production of commodities versus non-market functions.
- If possible, *threshold values* should be defined for indicators.
- The method should be validated with respect to
    - the *appropriateness* of its set of objectives relative to its purpose,
    - the *consistency* of the values of the indicators in relation to observed values,
    - the *adoption* of the indicators and/or the assessment method by the end users.

Table 2. Characteristic used to evaluate indicator-based environmental impact assessment methods (van der Werf & Petit, 2002 and Payraudeau & van der Werf, 2005)

Characteristic	Content
What is evaluated?	Environmental impact/performance ↔ ecological sustainability
Object studied	Product, farm (production site), region
Intended users of the assessments' results)	Policymakers, farmers, advisors, researchers, consumers,…
Dimensions considered	Only environment, or also economy and sociology
Spatial Scale of evaluation	Local, regional, global or multiple types of effects taken into account
Temporal scale	Year, product lifespan,…
N° of environmental objectives/themes	Input related, emission related, system state related
Basis of indicators	Effect based indicators ↔ means-based indicators
Time for data collection	Days per year
Format of output	Values, scores (only positive or also negative)
Thresholds	Yes/no. Different types of thresholds
Weighting of indicators	Yes/no. If yes, directly or indirectly
Aggregation of indicators	Yes/no. Different aggregation methodologies

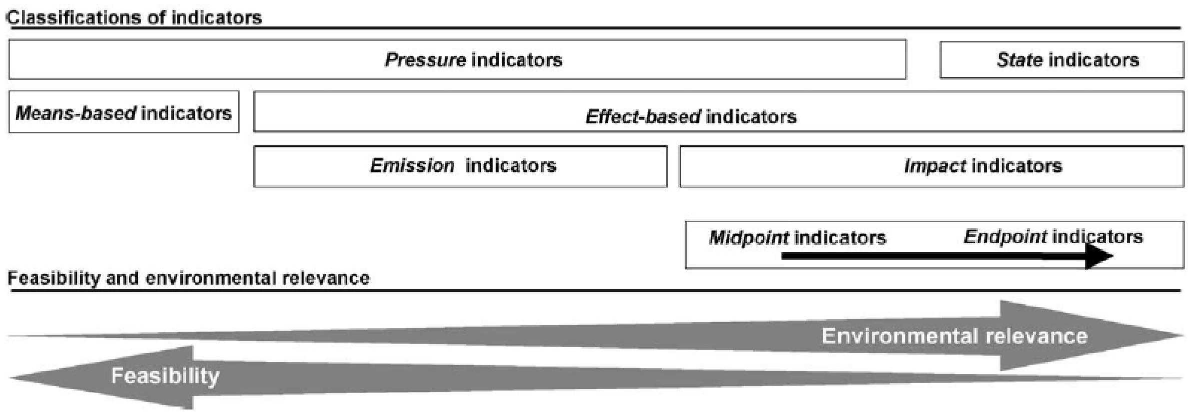


Figure 1. Classification of indicators according to their position in the cause-effect chain linking production practices to environmental impacts, trade-off between feasibility and environmental relevance (Payraudeau & van der Werf, 2005)

Galan *et al*. (2007) aimed to offer farmers a *relevant* and *user-friendly* environmental analysis tool, to perform the farm level environmental analysis required by the ISO 14 001 standard. To find such a tool, they evaluated 5 tools used in France using the characteristics in Table 3.

Table 3. Characteristics for farm level environmental evaluation tools (Galan *et al.*, 2007)

Characteristic	Content
Production type	Crops, animal husbandry, market gardening, viticulture, etc.
Spatial scale of evaluation	Farm, field
Implementation time	N° of days
Target user	Farmer, technician, researcher, …
Themes and impacts taken into account	Water quality, air quality, …, social environment
Farm activities (practices) taken into account	Crop protection, fertilisation, …, cropping pattern & rotation, "non-productive" elements, construction/modification of buildings, …
Type of raw data	Field practices, site practices, sensitivity of the environment
Aggregation level	Simple / composite / systems indicators
Aggregation method	Addition, expert system, …
Threshold values	Yes/no. Different types of thresholds

From this analysis the authors conclude that an environmental analysis tool at the farm level should satisfy following criteria:

- specify the farming system concerned, so as to identify all the potential impacts of the farming activities,
- be exhaustive in terms of environmental themes,
- choose indicators which take into account the sensitivity of the environment and the farming pressure, and that are suited to the spatial scale required by the action plan,
- act as a dashboard for the impact of practices,
- integrate local & regional environmental issues, in order to rank impacts at farm level,
- enable the elaboration of an action plan and thus highlight the causes of the impacts,
- be easy to use.

Bockstaller *et al*. (2006, 2009), in their review of methods to assess environmental sustainability of agricultural systems, confirm the multiplicity and variety of indicators and methods available. They point out that many methods are not evaluated for their scientific relevance and feasibility and that foregoing authors only use a set of qualitative or semi-quantitative evaluation criteria to compare the methods, but don't compare the outputs or conclusions of the methods. In order to "guide potential users of indicators or an evaluation method in their choice", in the COMETE project, they thus used a two-step evaluation of four methods based on a set of environmental indicators. First, they did a comparative evaluation, using a list of criteria which were grouped into three domains: "*scientific soundness*", "*feasibility*" and "*utility*" (Table 4). Second, they tested the implementation of the methods in a set of 13 farms.

Table 4. Evaluation criteria used in the COMETE project (Bockstaller *et al.*, 2006)

Scientific soundness	Feasibility	Utility
Coverage of environmental issues	Accessibility of data (for 3 user groups: farmers, advisers, administration)	Coverage of needs
Coverage of agricultural production branches	Qualification of user	Clearness of conclusion from results
Coverage of production factor	Need for external support	Quality of communication of results
Indicator type (driving-force, pressure, state, impact, response)	User-friendliness	
Depth of environmental analysis		
Avoidance of incorrect conclusions	Integration with existing farming software	
Transparency	Time requirement	

Proceeding to integrated sustainability assessments (ISA) Binder *et al*. (2010) structured their analysis of the characteristics of assessment methods along three dimensions: *normative*, *systemic* and *procedural* (Wiek and Binder, 2005). They thus explicitly separated the question of whether a system is properly described by means of the set of indicators used (systemic), from the question of how to assess whether the studied system is sustainable (normative), and from that of how the assessment was carried out (procedural). Figure 2 shows the relationship among the 3 dimensions and the characteristics used to describe assessment methods within each dimension. Using this framework they categorized methods into three types: (1) *top-down* farm assessments; (2) *top-down* regional assessments with some stakeholder participation; (3) *bottom-up*, integrated participatory or transdisciplinary methods with stakeholder participation throughout the process. Binder *et al*.'s analysis of 7 farm and regional level assessment methods showed that the type 3 methods contribute best to filling the current needs of agricultural sustainability assessment.

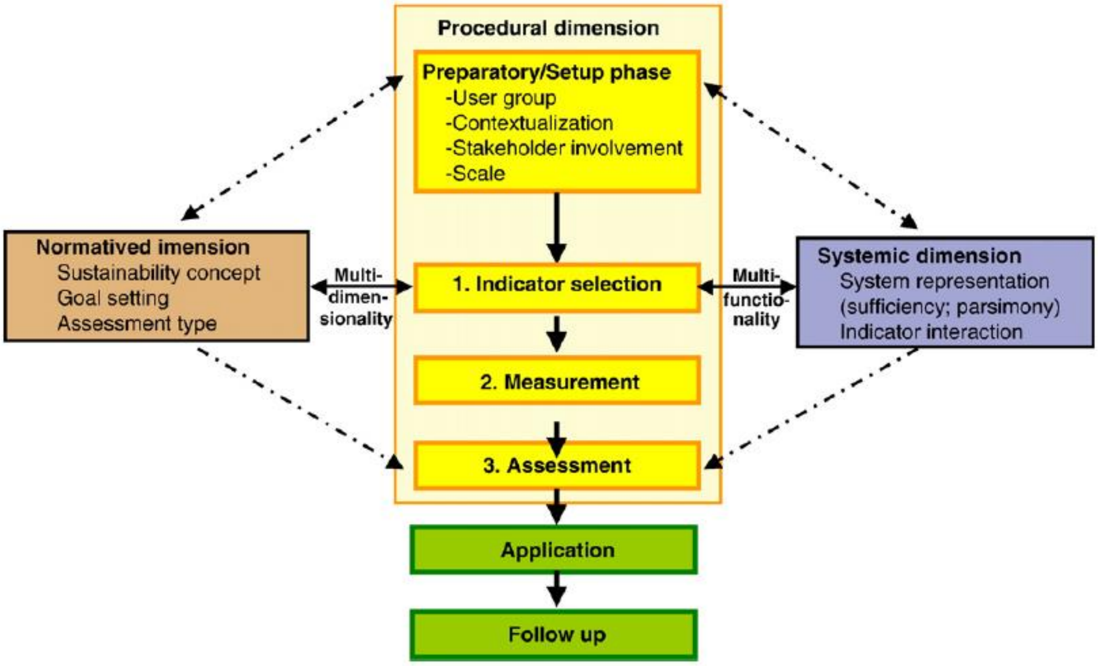


Figure 2. The relationship among the normative, systemic and procedural dimensions within a sustainability assessment process and the characteristics used to describe assessment methods within each dimension (Binder *et al*., 2010)

Sieber *et al*. (2012) specifically analysed four ISA approaches for their level of stakeholder participation. They consider stakeholder participation in (1) the framework development, (2) the integrated assessment process itself and (3) the tool/method application including the result presentation and analysis. Like Binder *et al*. (2010), they find the success of actual ISA tool use is high, if all levels have a strong stakeholder participation.

Marchand *et al*. (2014) focused on the key characteristics for tool choice in sustainability assessment at farm level. They derived 11 key characteristics by combining the framework from Binder *et al*. (2010) with the critical success factors for implementation of integrated sustainability assessment tools according to De Mey *et al*. (2011) (Table 5). Two additional characteristics enhanced the final set of characteristics: "output accuracy" or precision of the results (Schader *et al*., 2014) and "tool functions" (de Ridder *et al*., 2007). For the 11 characteristics, we observed a continuum between two extremes: a full sustainability *assessments* (FSA) and a rapid sustainability assessment (RSA) (Figure 3). FSA tools make use of detailed farm data and/or expert information, need trained advisers and/or expert visits to gather the data, and are rather long and expensive in duration. RSA tools represent the other side of the spectrum. They make use of the farmer's knowledge or readily available data, allow an audit by the farmer or an adviser, and are relatively short in duration.

Table 5. Critical success factors for implementation of integrated sustainability assessment (ISA) tools (De Mey *et al.*, 2011)

Critical success factor	Description
Attitude of model users towards sustainability	Values and beliefs of the model users (advisers and farmers) regarding sustainability issues.
Compatibility	Extent to which the design and the proposed use of the tool are compatible with the data systems and institutional structure of accountancy/consultancy agencies.
User-friendliness	Extent to which the ISA-tool is flexible and easy to use. This is related to the graphical design, ease of assessment, and calculation (automation), etc.
Data availability	Availability of data necessary for indicator calculation.
Transparency	Transparency of the used model and data (design, generalizations, etc.) and transparency on uncertainties of model-derived results.
Data correctness	Correctness of the data used to calculate the indicators of the ISA-tool.
Communication aid	Use of ISA-tool in discussion sessions and its ability to support discussion on sustainability. Both communication aid of the model itself as communication through using it in farmer groups are included.
Complexity	Degree of complexity of the ISA-tool.
Organization of discussion sessions	Practical organization of the discussion sessions with farmers. Which aspects need to be considered to make the discussion sessions more successful.
Effectiveness	Extent to which the ISA-tool is perceived as being relevant to use and implement.

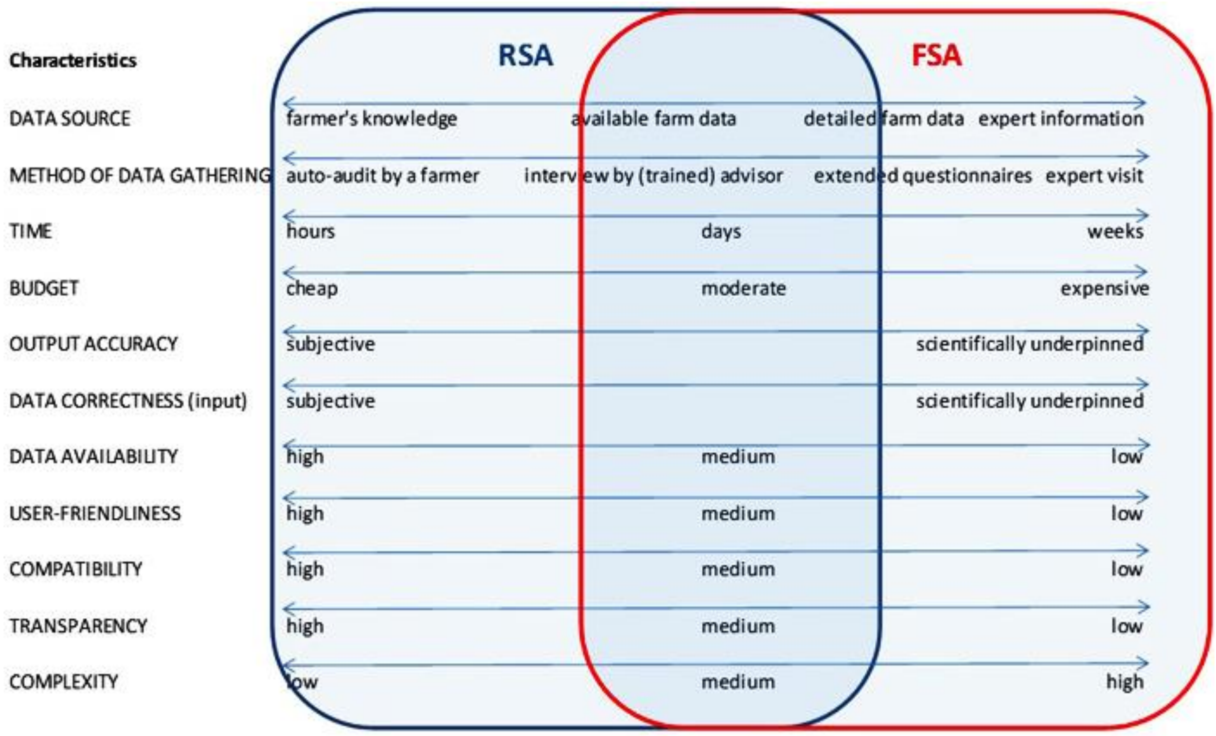


Figure 3. Characteristics describing full sustainability assessment (FSA) and rapid sustainability assessment (RSA) tools (Marchand *et al.*, 2014)

Schader *et al*. (2014) developed a typology for sustainability assessment approaches of food systems in terms of their *scope* and *precision*.

- *Scope* is characterised by primary purpose of the assessment, level of assessment, geographical scope, sector scope, thematic scope, and perspective on sustainability (Table 6).
- *Precision* in this context is "precision in the sense of measurement resolution", which reflects the ability of an approach to distinguish the outcome of changing situations, such as before and after an action intended to improve sustainability. This includes:
    1. whether qualitative, semi-quantitative, or quantitative assessments, where applicable, are used to generate results for a sustainability dimension;
    2. the thematic coverage of impact assessment categories within each sustainability dimension, i.e. the wider the coverage of topics within a sustainability dimension is, the more precise the dimension can be described;
    3. appraisal of the complexity of model algorithms;
    4. the time required for on-site data collection.

Table 6. Typology for characterizing and comparing the scope of the sustainability assessment approaches (Schader *et al*., 2014)

Criteria	Classes
Primary purpose	Research; Monitoring; Policy advice; Certification; Farm advice; Self-assessment; Consumer information; Landscape Planning
Level of assessment	Agricultural sector; Landscape/region; Field, farm; Product/supply chain; Standards
Geographical scope	• Applicable globally • Applicable to a specific country or region
Sector scope	• General, i.e., applicable to all agricultural / food products or farm types • Applicable to specific products or farm types
Thematic scope	Environmental; Social; Economic
Perspective on sustainability	• Farm/business perspective (Is the company economically healthy and developing on a resilient pathway?) • Societal perspective (Does the company contribute to sustainable development of society?) • Mixed perspective (Farm / business perspective and societal perspective are mixed)

Bockstaller *et al*. (2015) quote Hansen (1996), who distinguished different approaches to agriculture and sustainability, which each would explain different conceptual frameworks for assessment:

- sustainability as an <u>approach</u> of agriculture
    - an alternative ideology (1)
    - a set of strategies (2)
        - ⇨ Assessment methods implementing a scoring system of farmers' practices[1], e.g. IDEA (see Appendix 1 for references).
- sustainability as a <u>property</u> of agriculture
    - an ability to fulfil goals (3)
        - ⇨ Frameworks based on a set of general goals, often divided in more operational goals[2], e.g. life cycle analysis methods.
    - an ability to continue (4).
        - ⇨ Frameworks based on systemic properties, such as productivity, stability, reliability, resilience and adaptability or flexibility (López-Ridaura, 2005).

[1] called "*means-based*" by van der Werf & Petit, 2002 and Payraudeau & van der Werf, 2005, as seen above.
[2] called "*effect-based*" by van der Werf & Petit, 2002 and Payraudeau & van der Werf, 2005.

Bockstaller *et al*. (2015) continue by stating that sustainability frameworks can be characterised by preliminary choices and assumptions, i.e. the answer to a set of questions:

- Issues regarding sustainability: *Why to evaluate?*
- End-users: *To evaluate for whom?*
- Objectives or usages: *To evaluate for what?* (1) *ex post* evaluation, (2) *ex ante* decision support, (3) communication, implying a limited number, easy to understand indicators.
- Content: *To evaluate what?* E.g. strategies, goals, etc.
- System boundaries:
    - spatial scales: *To evaluate where?* E.g. taking "on-site" and/or "off-site" (outside the system) effects into account
    - temporal scales: *To evaluate* when?
- Feasibility in terms of means and resources.

Schindler *et al*. (2015), finally, presented a review of methods to assess farming sustainability in developing countries. The characteristics they use do not differ substantially from the ones listed before for temperate agriculture countries. Ten approaches used in sustainability impact assessment are characterised by their

- General application characteristics:
    - Moment of application: *ex ante*, monitoring or *ex post*;
    - Time for application of the framework;
    - Data type (primary, secondary);
    - Level of application and spatial scale (farm, local, regional, national);
    - Analysis type (qualitative and/or quantitative);
    - Assessment time perspective (short, medium, long term);
    - Whereas the "user" in earlier studies is often not specified, here a distinction is made between
        - Applying user (the one implementing the assessment),
        - End user of results.
- Stakeholder involvement and learning:
  Schindler *et al*. (2015) postulate that the involvement of stakeholders is a central aspect of sustainability impact assessment. Therefore they discuss these aspects more in-depth. The level of stakeholder involvement varies considerably in the methodological procedures presented, from active participation of multiple-level stakeholder representatives at several stages of the assessment procedure, over involvement during context analysis and in discussions and decision-making after the assessment process, to little or no involvement. Moreover, "learning and exchange is an essential element of sustainability assessment". "It requires horizontal as well as vertical interaction of multiple level stakeholders." Therefore different types of stakeholder should be integrated and involved them from the planning through to the final evaluation stage of an initiative.
- Sustainability dimensions:
  All sustainability impact assessments integrate the three pillars of sustainable development, but not all methodological approaches consider these dimensions in equal terms. Interrelations or trade-offs are seldom taken into account. Moreover, sustainability assessments should also factor in an institutional dimension, as institutional capacity is a significant means for facilitating movement towards sustainable development. Participation and governance are critical elements of the institutional dimension.

3.2 Selection of the characteristics to be surveyed

In three steps we made a selection of the characteristics for screening/evaluation of sustainability assessment frameworks, metrics and tools.

The first step was to list the characteristics found in literature as described above. A list of 70 characteristics was thus compiled. From this list it soon became clear that the meaning given to a certain characteristic can vary between authors. Bockstaller *et al*. (2009) already reported this problem for characteristics such as “relevance” or “sensitivity”. Some authors mainly link the latter to the availability of data, whereas for others it covers more aspects. Inversely, highly similar definitions can sometimes be named differently by different authors.

In the second step the definitions given in literature were studied in-depth. Characteristics with high similarity were clustered and working definitions were formulated. A list of 41 characteristic emerged.

In the third step the characteristics for further screening and evaluation of assessment methods were selected from the purified list. During several discussions between the authors, an intuitive selection was made, based on our combined expertise. The list was thus further reduced to 25 essential characteristics, for which definitions were univocally formulated. Finally, the characteristics were grouped into general assessment related information, information related to stakeholder participation and indicators related information (Table 7).

Based on these characteristics, a survey was developed that was sent to the developers or users of the assessment frameworks, metrics and tools selected in chapter 2. Qualtrics Research Suite was used to build a web-based questionnaire. E-mails were sent out to the assessment developers/users, inviting them to take part in the survey and providing them with a link to the questionnaire. The complete questionnaire can be found in Appendix 2.

Table 7. Characteristics used for further screening and evaluation of assessment methods in this study

Characteristic	Definition
ASSESSMENT RELATED CHARACTERISTICS	
origin	developed in which country or countries
initiative	developed on the initiative of ?
dating	year of development
scope of assessment	dimensions of sustainability considered (economic, environmental, social, governance, cultural)
perspective on sustainability	perspective on sustainability within scope (definition of sustainability used): societal or farm(er)'s point of view
primary purpose of the assessment	the intended function of the tool: reporting (obligatory), communication (non-committal), firm development, research, certification,…
level of assessment	Spatial scale of the assessment: field, farm, industry, chain, national/regional, landscape, global, product,…
sector scope	The assessed farm type or production type: general (applicable to all agricultural/food products or farm types; applicable to specific products or farm types (+ define which one)
system representation	Is the system represented in a reductionist (few indicators are used to assess the sustainability of a whole system) or holistic (reflects the complexity of a system by using many divers indicators) way?
applying user	The one applying the assessment: individual farmers, extension workers, policy makers, researchers,… or a combination: farmer and extension (Schindler *et al.*, 2015)
end-user of results	The end-user of the results: individual farmer, farmers in discussion groups, extension workers, policy makers, researchers,… or a combination: farmer + extension/farmers in discussion groups (Bockstaller *et al.*, 2015; Schindler *et al.*, 2015)
time for data collection	Time requirement for data collection (categories: < 2 h; 2-4 h; 1 day; 2 days; > 2 days)
method of data collection	method of data collection: interview (individual farmer + extension worker); audit (control system); self-assessment (tools that can be used and interpreted individually); other
aggregation & weighting	Are the indicator scores aggregated? Yes, No; If yes, is it a weighted aggregation? To which level?; If yes to weighing, method of weighing?
transparency	Are there reports/documents available for users regarding: content, purpose, method of assessment, indicator scores, interpretation of results, other?
level of implementation	Is the assessment being used, implemented? If yes; specify: only on a project basis, commercially used, used by farmers, used for certification, other

Table 7 (continued)

STAKEHOLDER PARTICIPATION	
What was the type of stakeholder participation for every phase of the assessment?	
stakeholder participation when?	Following the 6 stages defined by Binder *et al*. (2010): *(1) Preparatory phase:* defining context, goal and challenges; *(2)* Indicator *selection:* choosing the appropriate sustainability indicators, taking decisions on including interactions between indicators and how to weight indicators; *(3) Indicator measurement*: quantification of indicators and processes (use of statistical data, surveys or categorized qualitative data); *(4) Aggregation of indicators:* taking decisions on whether or not to aggregate indicators, to which extent and how; *(5) Applicability* of the assessment results: the process of getting the generated knowledge ready for utilization in practice; *(6) Follow-up:* reporting results, developing management advice, monitoring of indicators over time.
stakeholder participation who?	Who was involved? (farmers, extension workers (advisors), researchers, policy makers, civil society,…)
stakeholder participation how?	What type of stakeholder participation? (interviews, focus groups, workshops, other)
INDICATOR RELATED CHARACTERISTICS - ACCURACY OF METHOD CALCULATION	
indicator type	Primarily quantitative; primarily qualitative; equally quantitative and qualitative indicators
level of data input	Are the data needed to complete the assessment at field level, farm level, product level, region level or other?
data source	type of data used: accountancy, farmers' knowledge, expert information, field practices, site practices, other
number of topics	What is the number of topics for this dimension? • Number of themes • Number of indicators
reliability of data input	Are the data used for assessing correct and reliable? Yes, for all indicators within this dimension; yes, for most indicators of this dimension; no, data input for many indicators is doubtful
validation of calculation method	Are the calculation methods validated? If yes, what type of validation was used?
scoring system	What kind of scoring system was used for scoring the indicators of this dimension? benchmarks: which method is used?; expert based scoring: which method is used?; scoring from literature; other

4 ANALYSIS OF ASSESSMENT CHARACTERISTICS

4.1 Descriptive analysis

For a first analysis of assessment characteristic, 53 integrated sustainability assessment (ISA) methods were selected for the frameworks, metrics and tools inventory (as described in section 2.2). For 51 of these ISAs we managed to retrieve the contact persons who either developed the ISA or/and are currently using it. In the first week of October, we all sent them an e-mail invitation to fill out the questionnaire and a link to the Qualtrics e-questionnaire.

Responses to the survey came in quite slow and often only after several reminders, some as late as the last week of November. Finally we managed to get information on 38 ISAs, i.e. a 75 % response rate. We feel confident that this sample is representative for the ISA methods selected from the inventory in Appendix 2, based on the criteria described in section 2.2. We feel no specific ISA type or origin was left unsurveyed and that non-response was sufficiently random.

4.1.1 General assessment characteristics

4.1.1.1 ISA origin

In Figure 4 the countries from which the ISAs in the survey originated were set out on a map of the world's climate zones. The majority of ISAs was developed in western Europe, followed by ISAs developed for the international level. Only a few ISAs originated from North and Central America and one from New Zealand. The distribution of origins in the survey responses reflects the origins in the frameworks, metrics and tools inventory, in which ISAs from eastern Europe, Asia, Africa and South America are scarce or even lacking.

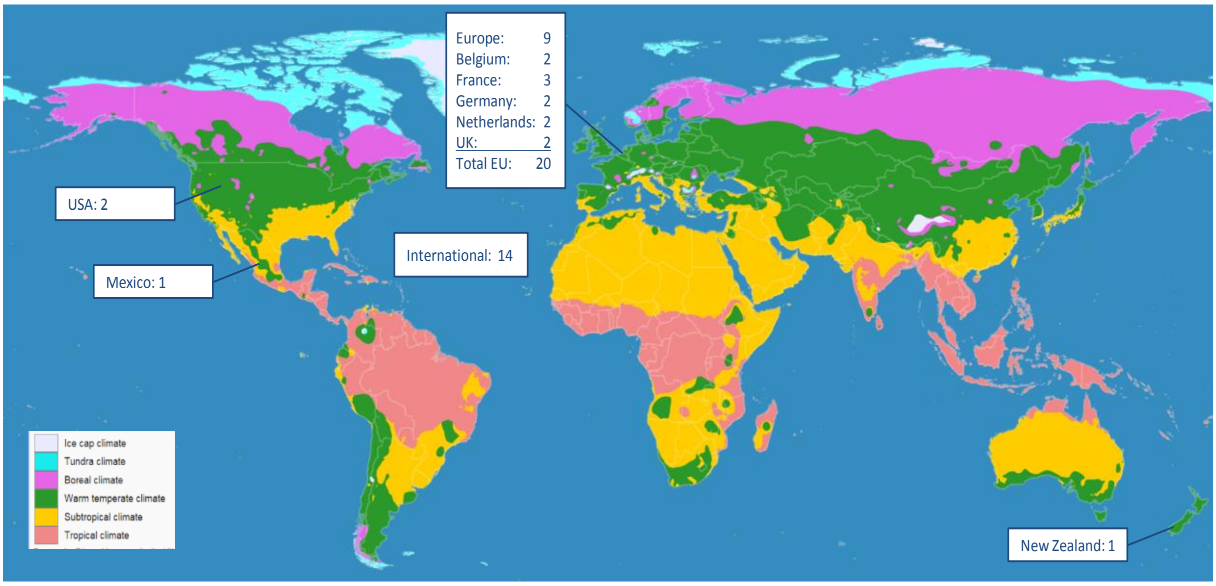


Figure 4. Distribution of tool origins in the survey responses in relation to earth's temperate climate zones (in green) (Copyright climate zone map: LordToran by CC BY-SA 3.0).

4.1.1.3 Scope of the assessment

Figure 5 shows the distribution of the assessment scopes, i.e. the sustainability dimensions covered in the survey, Figure 6 shows the distribution of the number of dimensions per ISA. It needs to be kept in mind that to the best of our ability we only selected integrated methods, i.e. methods assessing preferably at least 3 dimensions. For all but 6 ISAs this indeed was confirmed (Figure 6). Almost all methods we received information about assess the economic, environmental and social dimensions (Figure 5). 10 ISAs also assess the governance dimension. 6 respondents claim to assess the cultural dimension, although for some interpretation confusion is expected. In this context, "culture" was meant as "the way of life, especially the general customs and beliefs, of a particular group of people at a particular time", while it might have been interpreted as "to breed and keep particular living things in order to get the substances they produce" (Cambridge Dictionary).

Other assessment dimensions mentioned include animal welfare, entrepreneurship, innovations, multifunctionality and services.

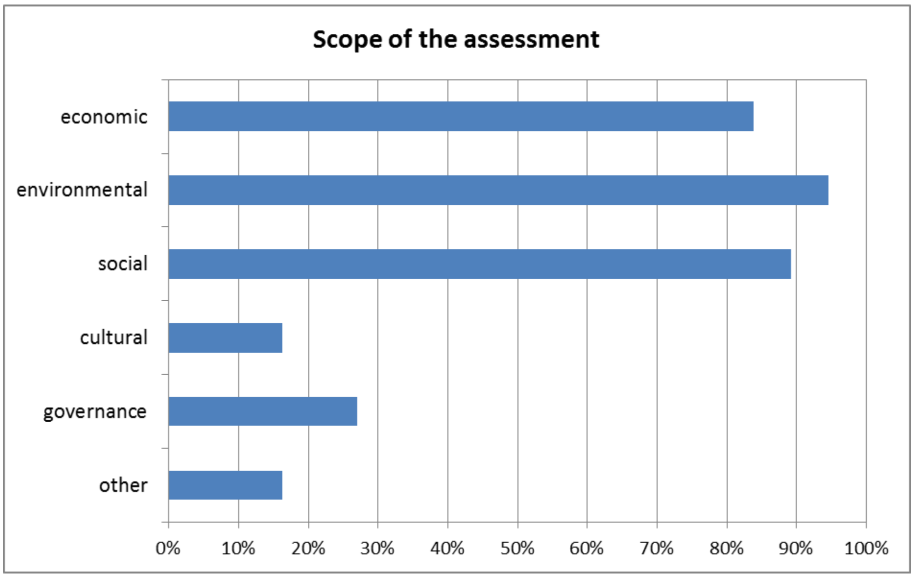


Figure 5. Distribution of the assessment scopes covered by the ISAs in the survey.

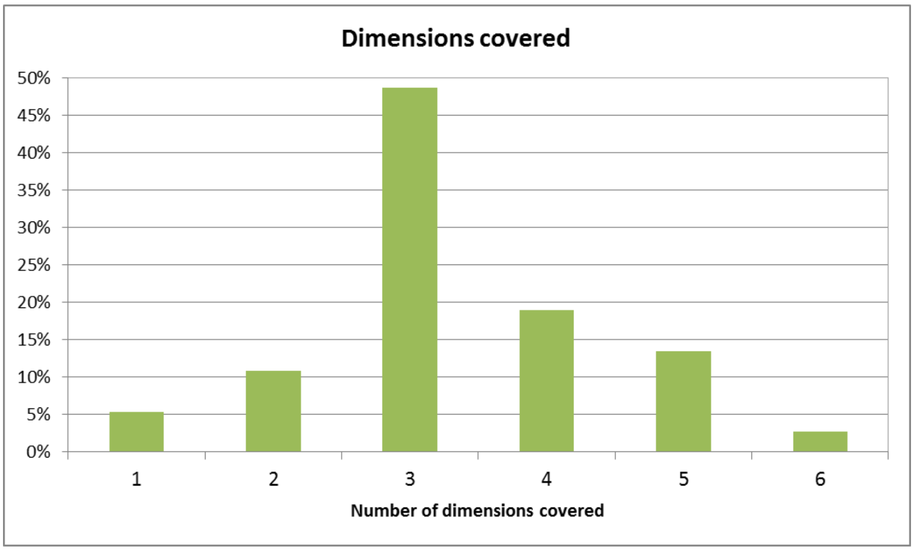


Figure 6. Distribution of the number of dimensions covered per ISA.

4.1.1.4 Perspective on sustainability

Figure 7 shows the points of view or perspectives from which sustainability is addressed. Only a minority of ISA methods (7) looks at sustainability purely from a societal point of view. 16 methods take the farm's perspective.

Most of the respondents ticking "other", indicate that their ISA method takes mixed points of view, e.g. “both societal and farm”, “farm and regional”, “societal and distributer and farmer”, etc. Also the “value chain” perspective is mentioned.

However, some respondents mention “parcel-level”, or “landscape-level”, which might indicate that they are talking about the assessment level in the sense of spatial scale (one of the following questions), instead of about the sustainability perception underlying their ISA.

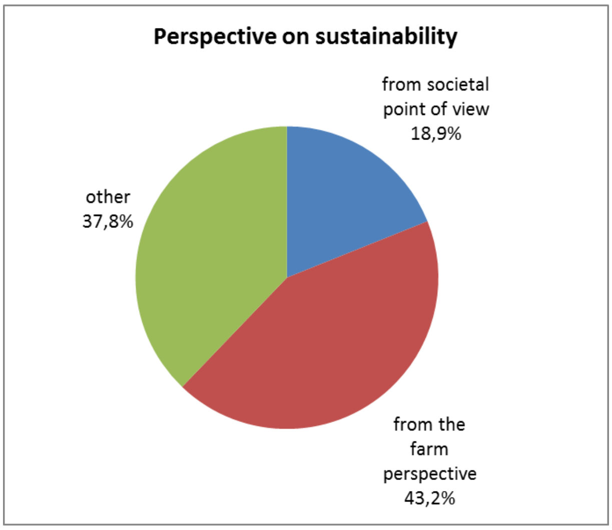


Figure 7. Distribution of the perspectives on sustainability found in the survey

4.1.1.5 Primary purpose of the assessment

The primary purposes or intended functions covered by the ISAs in the survey are shown in Figure 8. Farm development is by far the most important primary purpose. This can hardly be a surprise, since farm level assessment methods had priority to be taken in to the sample. It may be more interesting that for more than half of the ISA’s multiple purposes were reported (Figure 9).

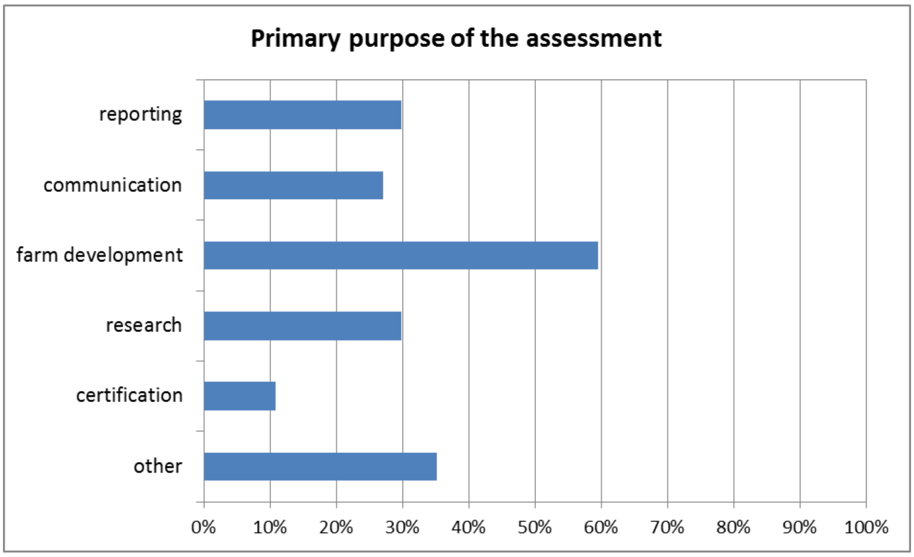


Figure 8. Distribution of the primary purposes covered by the ISAs in the survey.

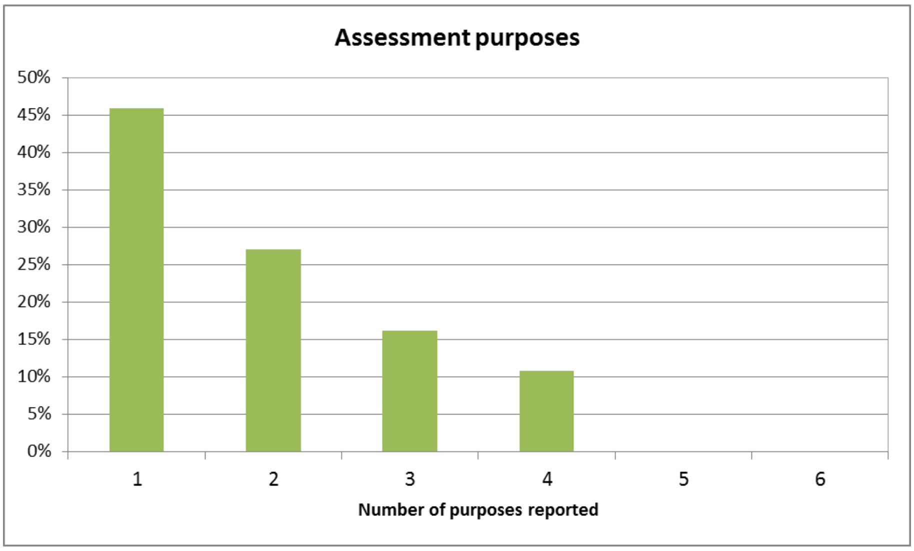


Figure 9. Distribution of the number of primary purposes per ISA.

Other purposes mentioned are e.g. impact assessment, identifying good practices, management optimisation, to start a dialogue on the concept of sustainable agriculture (debate and awareness), to get the farmer thinking about and talking about sustainability, learning at individual and sector level, supply chain improvement and policy assessment.

4.1.1.6 Level of assessment

Even more than farm development is a main primary purpose of the assessments, the farm is the main level of assessment (Figure 10). Indeed, purposes such as identifying good practices, management optimisation or thinking and talking about sustainability are also supported by farm level assessment methods. "Other" assessment levels mentioned are, among others, the organisational, the community and the sector level.

For 27 ISAs (73 %) only one level of assessment is reported.

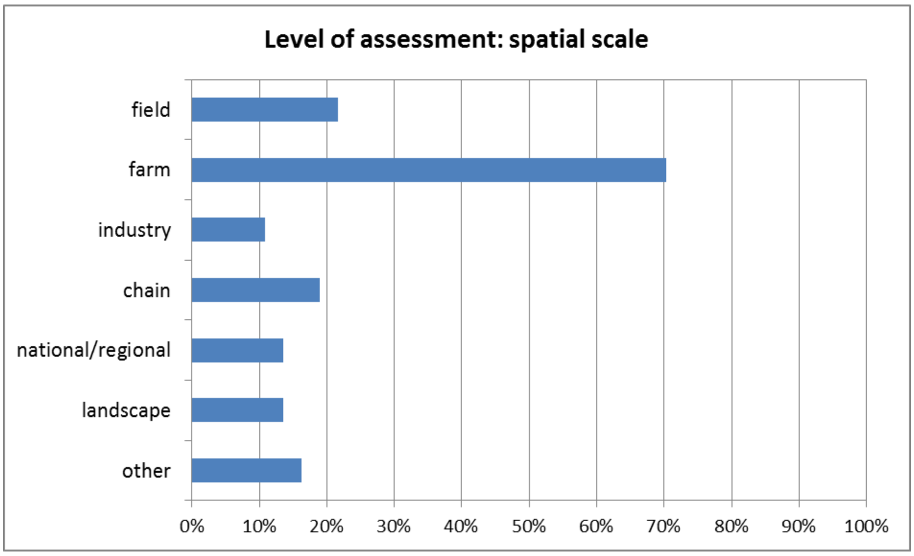


Figure 10. Distribution of the assessment levels adopted in the ISAs in the survey.

4.1.1.7 Sector scope

The majority of the ISA methods (26 out of 37) are general, i.e. they can assess all farm types. Some of them are developed and/or mainly used in specific farm/production types, e.g. DEXiFruits, Ben & Jerry's Caring Dairy. Some ISAs consider more than just farming , e.g. also forestry and fisheries (e.g. GlobalGAP, SAFA) or also the processing of agricultural commodities (e.g. Field to Market).

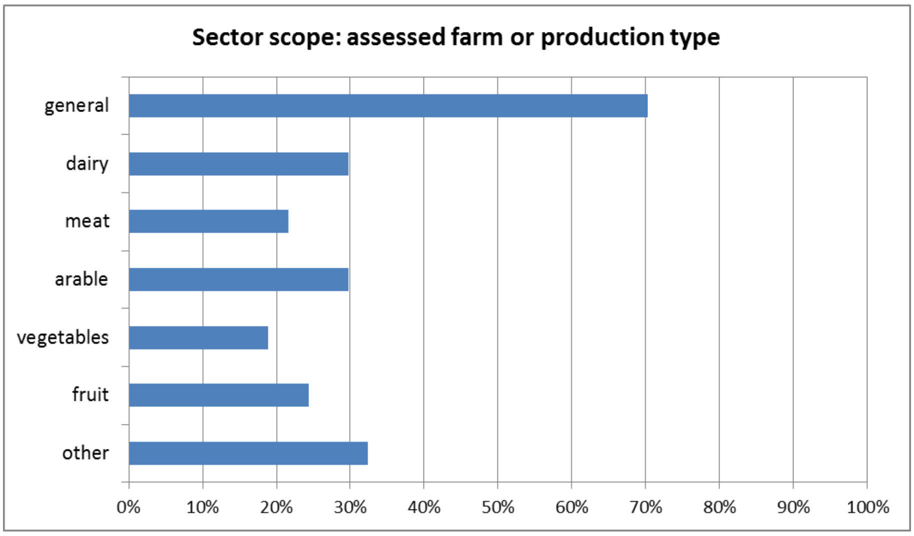


Figure 11. Distribution of sector scopes in the surveyed ISA's.

4.1.1.8 System representation

Figure 12 shows the ISAs' system representation, i.e. whether the system is represented in a reductionist (few indicators are used to assess the sustainability of a whole system) or holistic (reflects the complexity of a system by using many divers indicators) way. Only 2 respondents (5,4 %) claim that their ISA represents the agricultural system in a reductionist way (MESMIS and Sustainable Value Added). From the "indicators" section of the survey (that is discussed in section 4.1.3), it is revealed that the share of ISA methods using only 1 to 5 indicators to describe a particular sustainability dimension is: economic 24 %, environmental 7 %, social 16 %. So indeed there seem to be very few very reductionist ISAs in our survey. As the economic dimension is handled in a more reductionist way than the environmental dimension, many ISA methods indeed comprise a "combination" of representations.

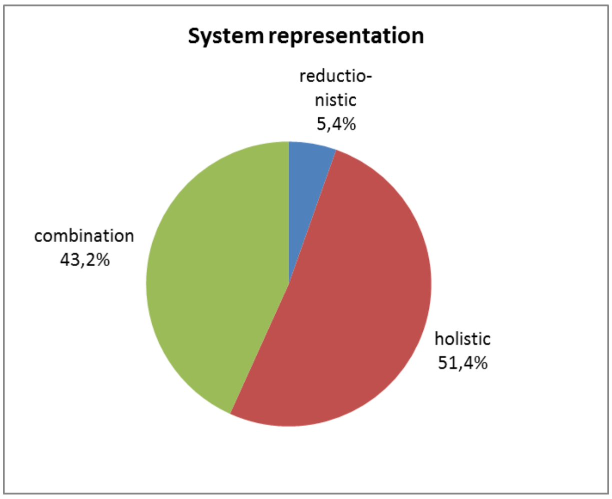


Figure 12. Distribution of the system representation in the surveyed ISA's.

4.1.1.9 Applying user

The applying users, carrying out the assessments, are quite diverse (Figure 13). In 18 ISA methods researchers are still involved in the implementation. Almost as important groups of applying users are farmers and extension workers (advisors, consultants). 17 respondents report combinations of 2 or more applying users (Figure 14), e.g. farmer + advisor (+ researcher) (+ civil servant), indicating that the assessment is a joint effort by several people with different functions. Other applying users mentioned are e.g. NGO's or supply chain actors.

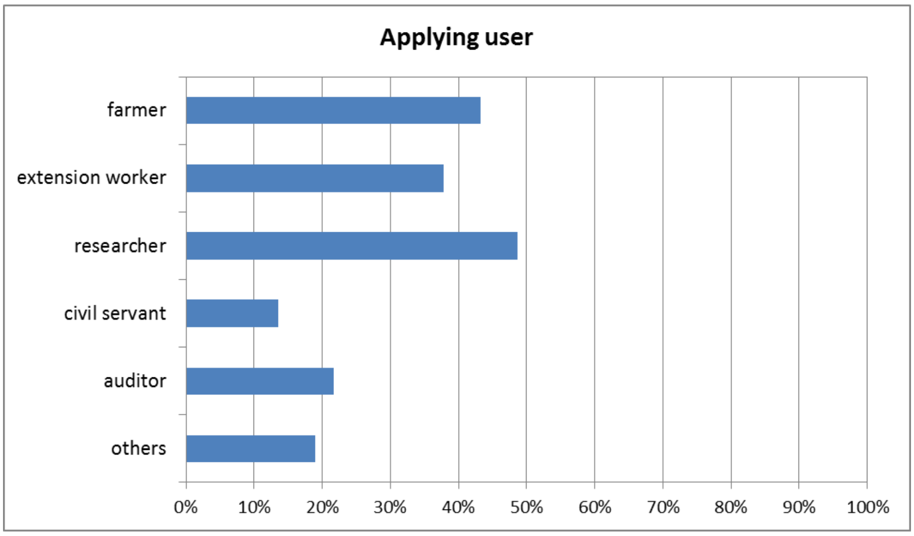


Figure 13. Distribution of the applying users carrying out the assessments.

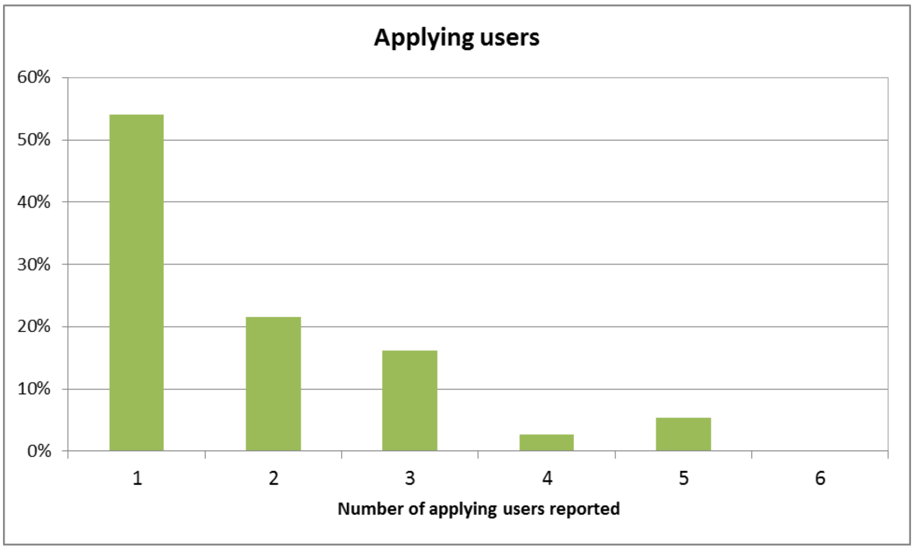


Figure 14. Distribution of the number of applying users per ISA.

4.1.1.10 End-user

Individual farmers are the end-uses of the result of 3/4 of the ISA methods. The results of 1/2 of the ISA methods can also be used in farmers' discussion groups (Figure 15). Only 3 respondents (out of 36 answering this question), claim their ISA has a single type of user. For all other ISAs multiple end-users are foreseen (Figure 16). Including the other types of end-users that could be entered under "others", up to 8 different types of end-users were reported (GRI G4 Sustainability Reporting Guidelines). Other end-users mentioned are quite diverse, e.g. students, policy makers, civil society, capital providers, operators in the supply chain, retailers, consumers, etc.

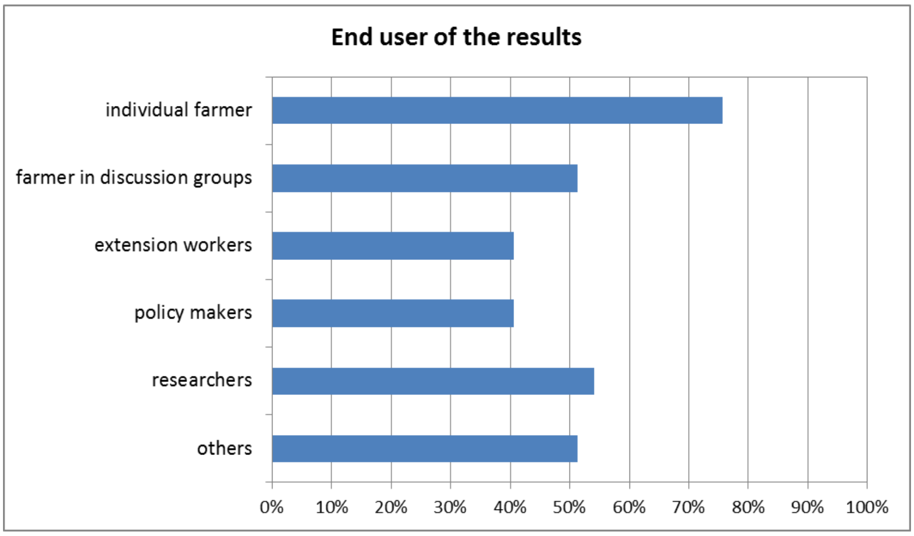


Figure 15. Distribution of the end-users using the results of the assessments.

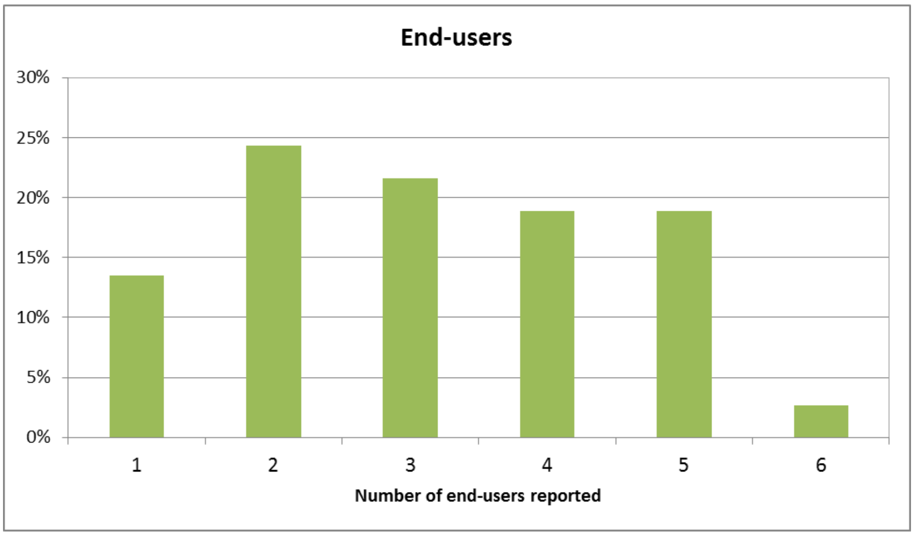


Figure 16. Distribution of the number of applying users per ISA.

4.1.1.11 Time needed for data collection

For only 5 ISA methods (14 %) it takes less than 2 hours to collect the data needed for the assessment. For 14 ISAs (38 %) data collection takes 2-4 hours (half a day). But there are also 12 ISAs for which data collection takes 2 days or more.

A quick glance at the numbers of indicators, shows some quite logical combinations, e.g. > 2 days to collect the 300 indicators that make up the OXFAM Behind the Brands Scorecard. Some combinations, however, seem counterintuitive, but can be explained by the method of data collection. For DEXiFruit, for example, it would take < 2 hours to collect the data to calculate 175 indicators, but existing databases complemented with expert knowledge are used. By contrast for the TOA-MD 5.0 model data collection for 8 indicators takes > 2 days, but the indicators need to be modelled.

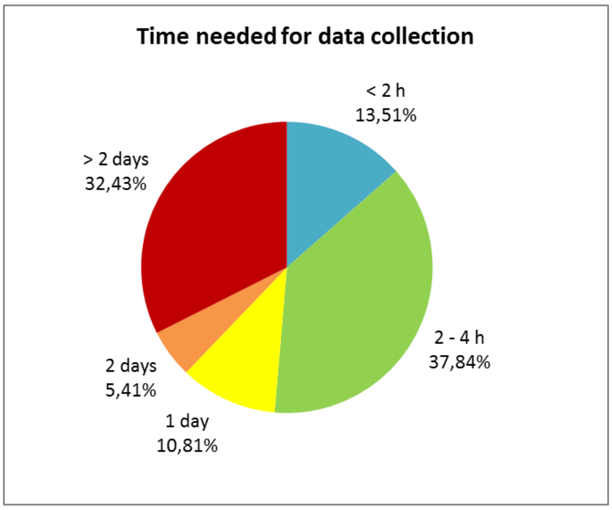


Figure 17. Distribution of the time needed for collecting the data needed to perform the assessment.

4.1.1.12 Data collection methods

The methods used for data collection are shown in Figure 18. Interviews and self-assessments are both used in over half of the ISAs. Audits are reported to be used in 7 ISAs. Other methods, apart from the ones already mentioned above, include field measurements, animal welfare appraisal by vets, focus group discussions, surveys, public data, literature, etc.

17 ISA methods make use of only one data collection method, 20 use combinations of methods.

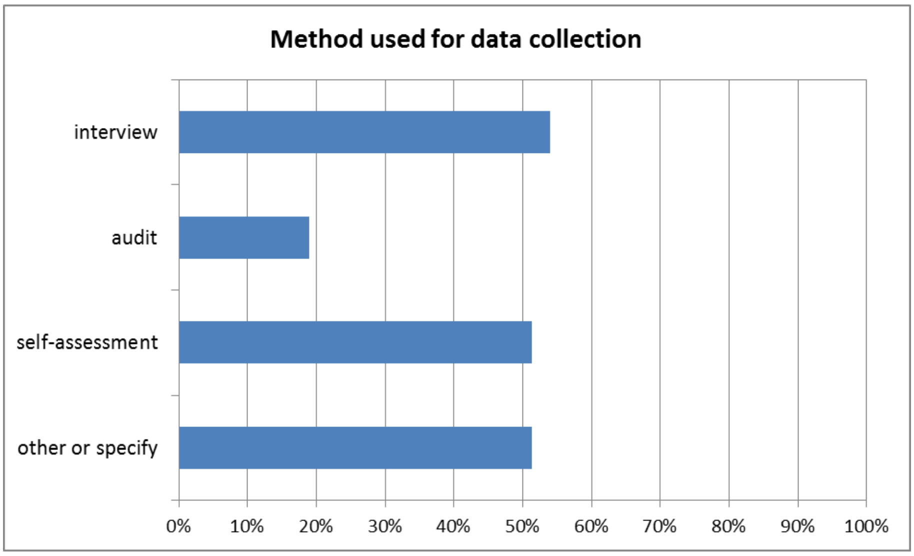


Figure 18. Distribution of the data collection methods used in the ISAs.

4.1.1.13 Indicator aggregation and weighting

2/3rd of the respondents indicate that the indicator scores are aggregated in their ISA (Figure 19). Aggregation methods are often meticulously described by the respondents and these descriptions deserve further studying. Examples are multi-criteria analysis, average scores per theme, simple sums and weighted sums.

From the 22 ISAs that apply indicators aggregation, 15 weight the indicator scores before aggregation (Figure 19). This means 41 % of the ISAs in our survey use weighted aggregation. Also here, a variety of methods is described. A few methods leave the weights open, to be determined *ad hoc* by different users.

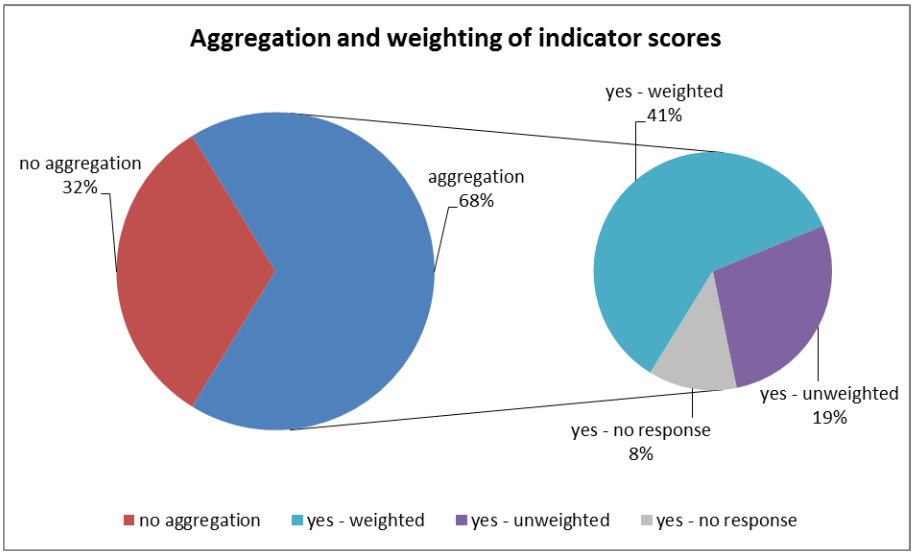


Figure 19. Aggregation of indicators scores and weighting in case of aggregation.

4.1.1.14 Transparency

Only 2 respondents state that no background documents are available about their ISA. Otherwise the ISA transparency seems quite well insured: for 10 ISAs documents are available on 5 topics, for 13 ISAs background documents are even available for all 6 topics mentioned in the survey (Figure 20).

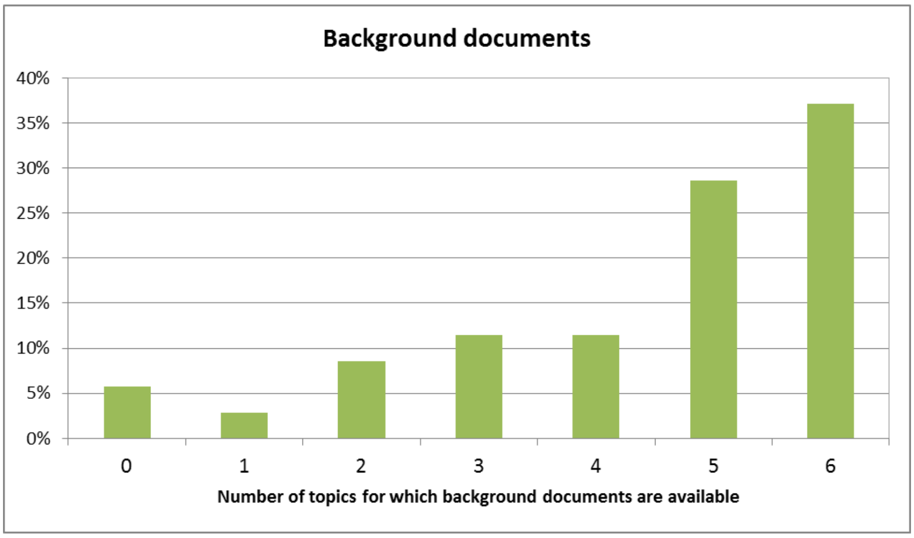


Figure 20. Distribution of the numbers of topics for which background documents available per ISA.

For the majority of ISA methods background documents are available describing content, purpose and methodology. In the later phases of ISA development, the share of ISAs with background documents decreases somewhat (Figure 21).

The aspects content, purpose, methodology, indicator scoring, indicator aggregation and interpretation of the results of the assessment methods roughly correspond with the 6 phases in the ISA development as defined by Binder *et al*. (2010) (also see section 4.1.2). It might be expected that stakeholder involvement in consecutive phases stimulates the ISA developers to draft documents or reports. The associations between stakeholder participation and documentation availability is discussed in section 4.2.3.3.

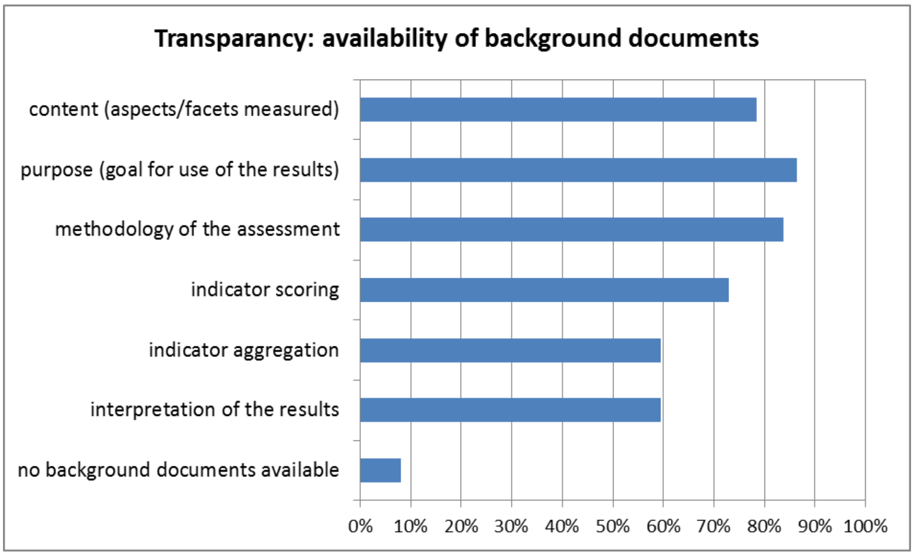


Figure 21. Distribution of the topics on which background documents or reports are available.

4.1.1.15 Implementation

The question "Is the assessment being implemented?" was answered by 34 respondents. 30 of them answered "yes". The large majority of the ISAs in our survey is thus being implemented in some way (Figure 22). We cannot know to what extent non-response, either to the whole survey or to this particular question, is connected to non-implementation of any particular ISA.

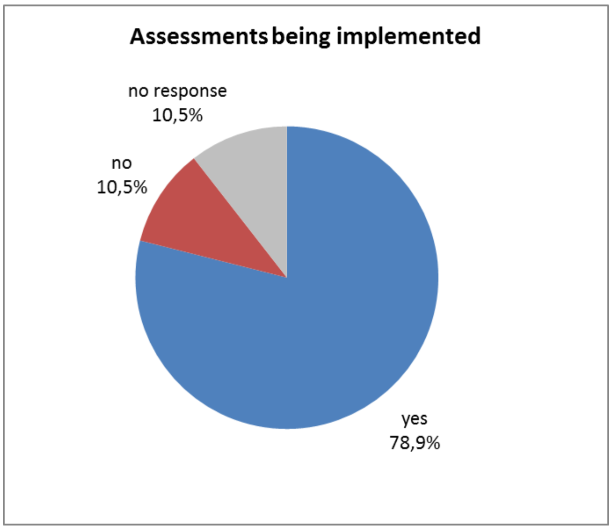


Figure 22. Distribution of ISAs being implemented or not.

Figure 23 shows how the assessments are implemented. 23 respondents state their ISA was implemented on project basis. 10 of them only ticked project basis, which might indicate that for 34 % of the ISAs, for which we received response, the implementation never went beyond the project were they were developed (yet).

For the ISAs that they declare to be used by farmers, the respondents almost always make a combination with commercial use or certification use. For 6 ISAs all 3 uses were entered. It should be noted that 9 ISAs are implemented in certification, while certification was a primary purpose for only 3 ISAs (Figure 8). Only 3 ISAs seem to be implemented for farmers' private use only, outside a commercial/certification context. All of these 3 are also linked to implementation on project basis.

Other uses are mainly policy support and teaching to students.

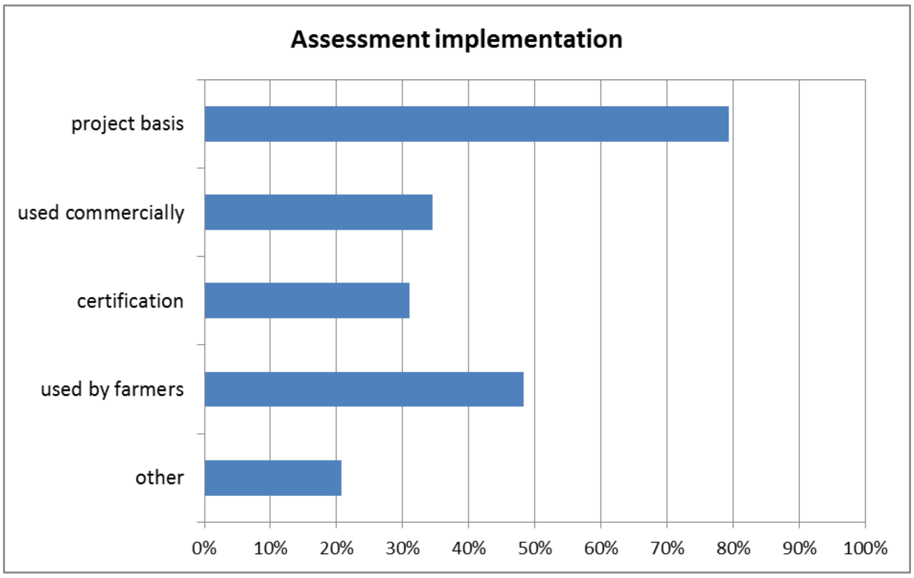


Figure 23. Distribution of the way in which the ISAs are being implemented.

4.1.2 Stakeholder participation

ALL 38 respondents state that stakeholders have been involved in the development or the implementation of their ISA methods.

To gain insight in the intensity and timing of stakeholder involvement, the ISA development and implementation was split into phases and in the survey we asked for each phase whether stakeholders were involved, which stakeholders were involved and which type of participation was used. The 6 stages of ISA development and implementation were defined as follows by Binder *et al*. (2010):

1. *Preparatory phase:* defining context, goal and challenges;
2. Indicator *selection:* choosing the appropriate sustainability indicators, taking decisions on including interactions between indicators and how to weight indicators;
3. *Indicator measurement*: quantification of indicators and processes (use of statistical data, surveys or categorized qualitative data);
4. *Aggregation of indicators:* taking decisions on whether or not to aggregate indicators, to which extent and how;
5. *Applicability* of the assessment results: the process of getting the generated knowledge ready for utilization in practice;
6. *Follow-up:* reporting results, developing management advice, monitoring of indicators over time.

Figure 24 shows the share of ISAs in our survey with stakeholder participation in each of the 6 phases. It reveals that stakeholder involvement is common practice in the first phases, i.e. in the defining the framework and on the indicator selection. Stakeholder participation falls back somewhat when indicator quantification and potential aggregation[3] are discussed. But even in the later phases stakeholders are still involved in the development and implementation of 71 to 79 % of the ISAs.

[3] Although it needs to be kept in mind that in only 2/3rd of the ISAs the indicators are aggregated.

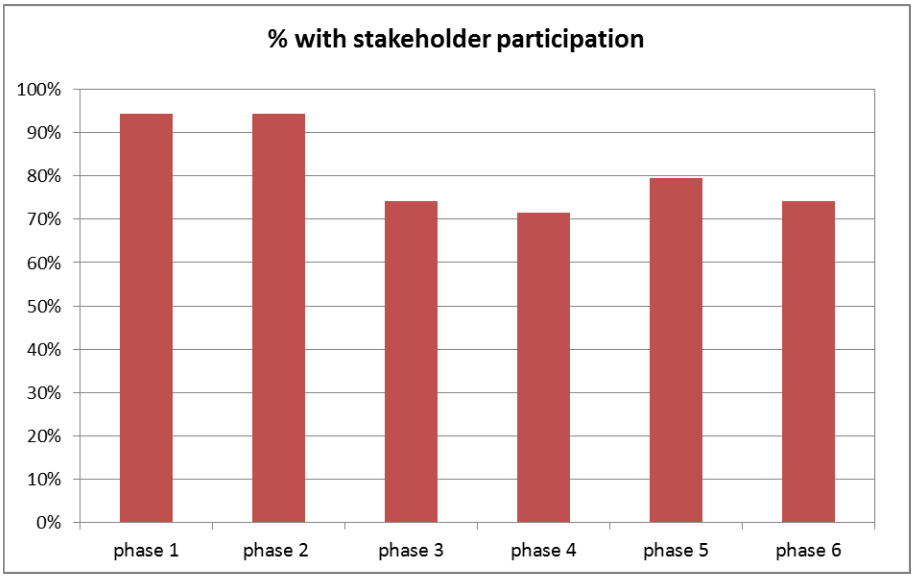


Figure 24. Percentage of ISAs in the survey with stakeholder participations in each of the 6 phases of ISA development and implementation.

Figure 25 gives an overview of the types of stakeholders involved in each of the 6 phases of ISA development and implementation. In all phases researchers are the most frequently involved stakeholders. In 2/3rd of the assessment methods, farmers were involved in the preparatory phase. Their involvement then deceases as the development progresses, but reaches 2/3rd again, in the last 2 phases (applicability of the results and follow-up). Extension workers (advisors) mainly intervene in the 3rd and 6th phase, i.e. in indicator quantification and in follow-up/implementation. If involved, civil society (including NGOs) and policy makers mainly intervene in the early phases. Food chain and retail representatives are the most consulted other stakeholders.

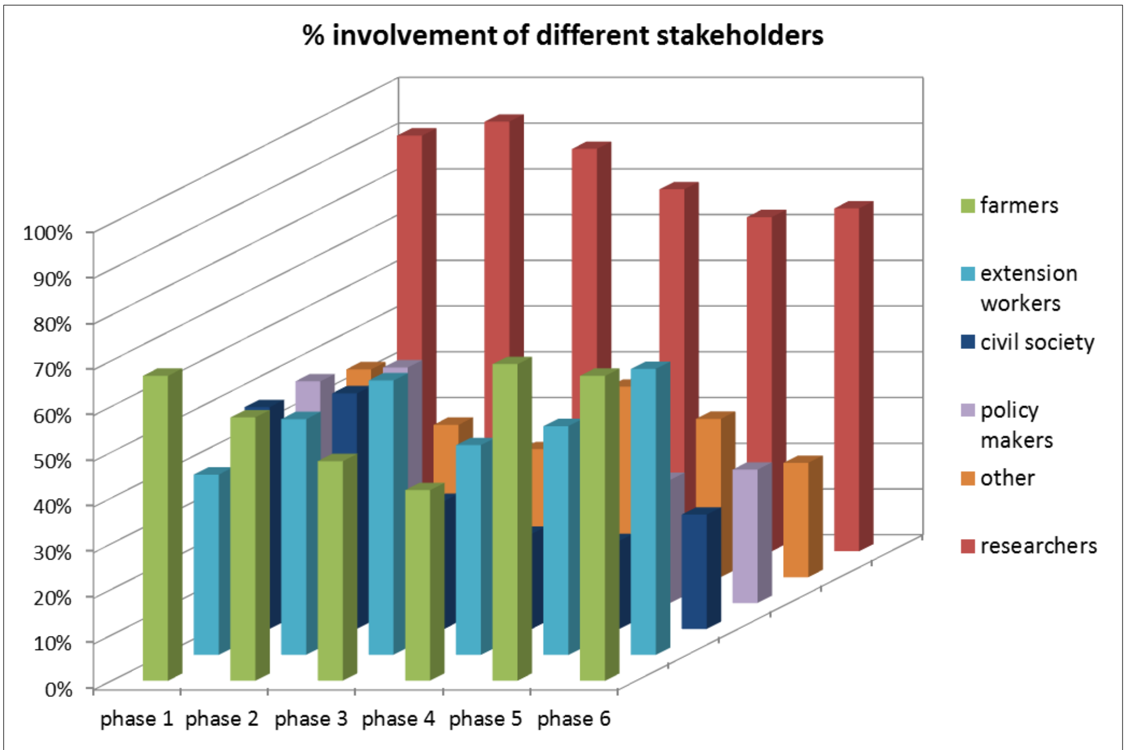


Figure 25. Percentage of ISAs in the survey in which different types of stakeholders are involved in each of the 6 phases of ISA development and implementation.

Finally, Figure 26 gives an overview of the methodologies used for stakeholder participation. Focus groups are most frequently employed (in 67 to 88 % of the ISAs, depending on the development phase). Especially in the preparatory phase focus groups are preferred over interviews or other types of stakeholder interaction. Other methods are not unimportant though, as they are employed in 22 to 46 % of the ISAs (depending on the development phase). The other methods for stakeholder participation are very diverse, e.g. questionnaires; other types of written feedback, possibly through online public consultation; student seminars; consultation of existing databases in phase 3; user feedback in phase 6; etc.

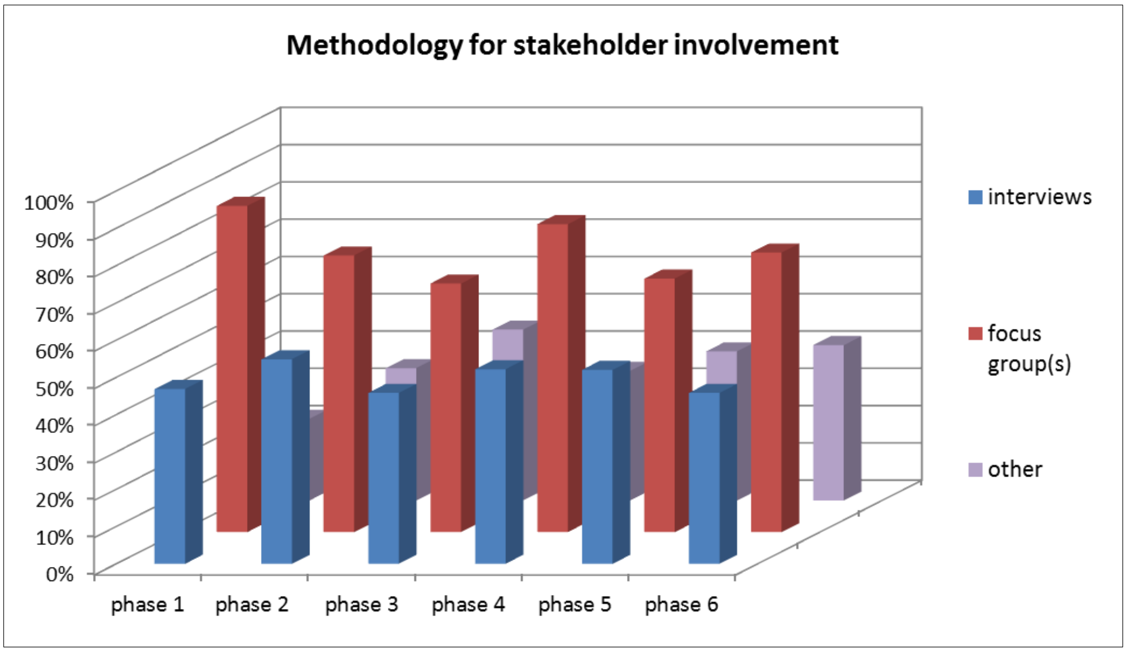


Figure 26. Percentage of ISAs in the survey in which different methodologies for stakeholder participation are used in each of the 6 phases of ISA development and implementation.

4.1.3 Indicator related information

Only 33 out of 38 respondents answered "yes" to the question whether indicator related information is available (2 answered “no”, 3 did not respond). Only if this questions was answered affirmative, and respondents had stated before that a particular sustainability dimension was assessed in their ISA, the subsequent questions on the indicators in each dimension were shown to the respondents. The following analysis is thus based on a variable amount of responses: 28 for the economic, 31 for the environmental, 28 for the social and only 8 for the governance dimensions.

4.1.3.1 Indicator types

Figure 27 shows the distribution of quantitative and qualitative indicators per sustainability dimension in the ISAs in our survey. For the economic and environmental dimensions mainly quantitative indicators are used, or a mix of quantitative and qualitative indicators. For the social dimension only few methods exclusively use quantitative indicators, for the governance dimension none do.

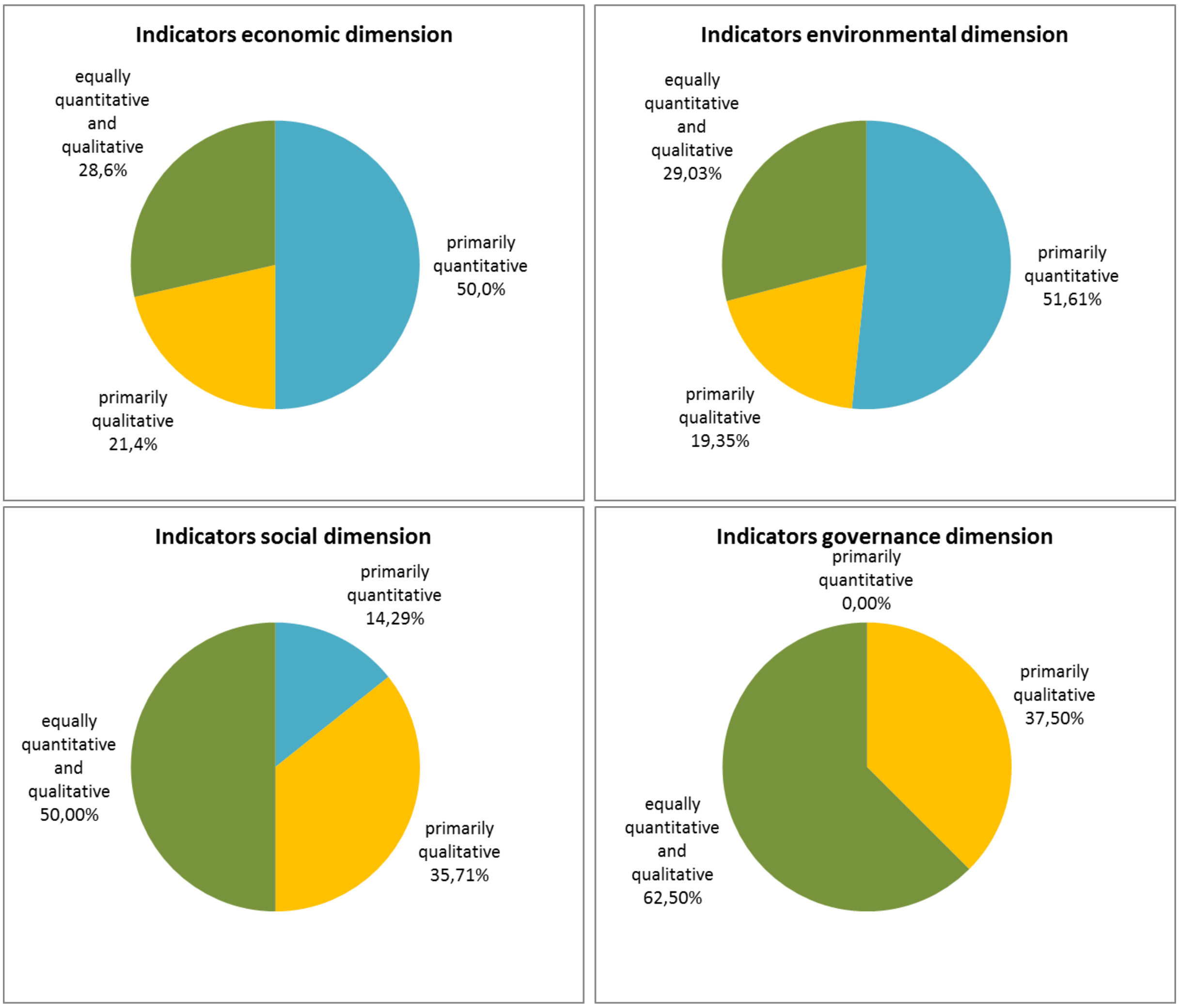


Figure 27. Distribution of the types of indicators per sustainability dimension used in the ISAs in the survey.

4.1.3.2 *Level of data input and data sources*

Figure 28 shows the levels of data input, Figure 29 the data sources for the main sustainability dimensions. For all dimensions the farm and the farmer are the main levels of data input. The field, product or region levels are less prevalent in the ISAs in our survey. Other levels mentioned include the supply chain, community, a mix of levels for the environmental dimension and the farm family for the social dimension.

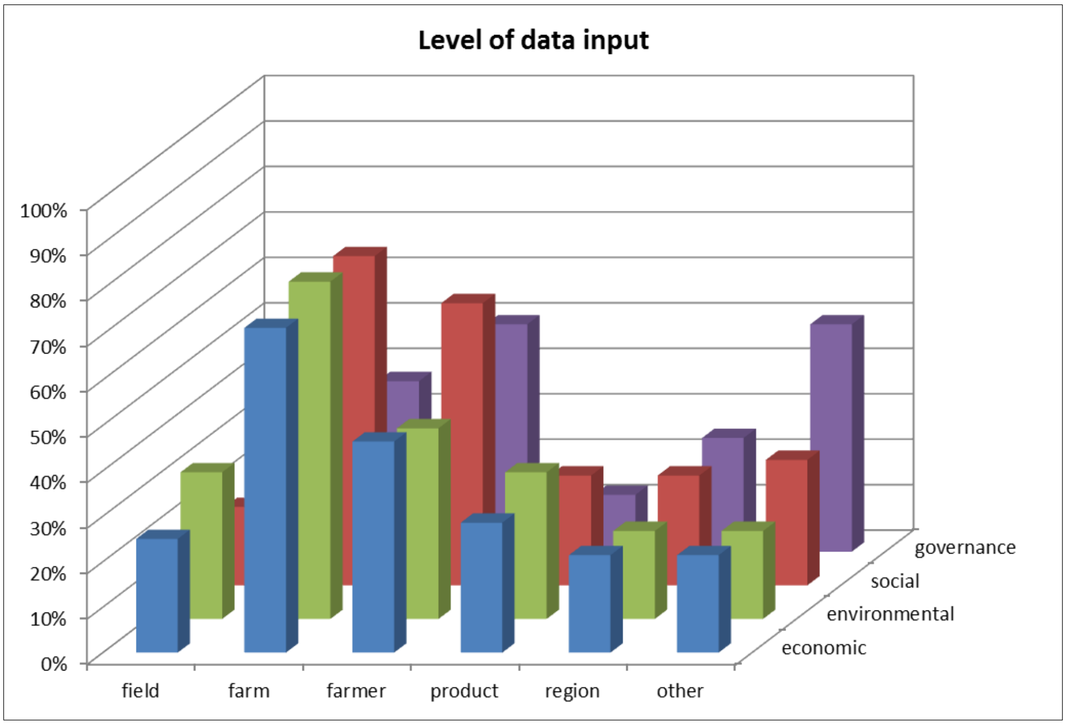


Figure 28. Distribution of the levels of data input per sustainability dimension for the ISAs in the surveys.

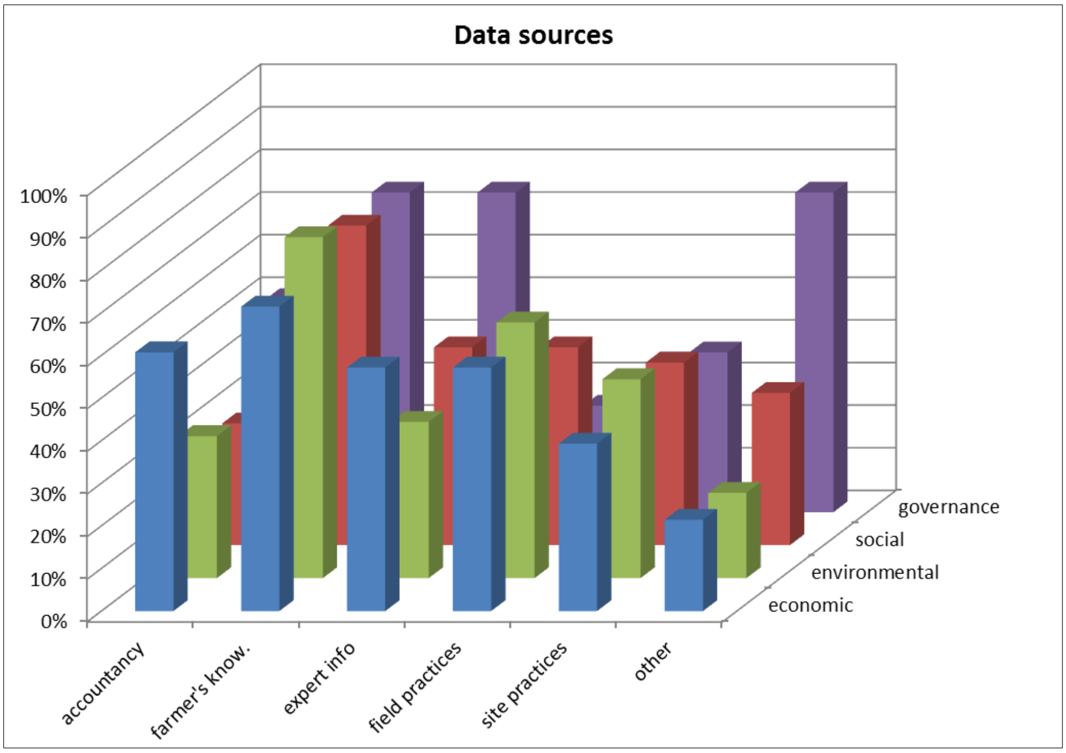


Figure 29. Distribution of data sources per sustainability dimension for the ISAs in the surveys.

Farmers' knowledge is the data source most tapped in to by sustainability assessment methods. It is used in about 75 % of the methods and for all sustainability dimensions. The accountancy is used as a source for economic data in 60 % of the methods. But also for environmental, social and governance data it is still used quite frequently. About half of the methods also needs expert information. Especially for the governance dimension expert info is important. Field and site practices obviously are mainly used as data sources for economic and environmental indicators. Still even for the social and governance indicators they are used in 25 to 46 % of the methods.

Other data sources mentioned for the economic dimension are literature and modelling; for the environmental dimension expert systems, such as the Global Water Tool; for the social dimension the community, regional sources, household survey, survey with farm workers; and local policies for the governance dimension.

4.1.3.3 Numbers of themes and indicators per dimension

Over the 33 ISAs in the survey a rather large variation is reported in the numbers of themes used to describe a sustainability dimension:

- for the economic dimension 1 to 6 and up to 19;
- for the environmental dimension 3 to 8, > 10 in 1/4th of the ISAs, up to 18;
- for the social dimension 2 to 7, up to 25;
- for the governance dimension 1 to 14.

These data, Figure 30 and median values in Table 8 clearly show that in the majority of ISA methods more themes are used to describe the environmental dimension than to describe the economic and social dimensions.

Two remarks need to be made concerning the number of themes:

- For the governance dimension no conclusive statement can be made, since there we have only 7 responses. It is possible that these 7 ISAs are among the more exhaustive ones.
- Ten or more themes within one dimension seems excessively much. Potentially some respondents had a comprehension problem with the term “theme”, in spite of the figure included to clarify the meaning of “dimension”, “theme”, “sub-theme” and “indicator”.

Table 8. Median numbers of themes and indicators per dimension in the ISAs in our survey

Dimension	Median numbers Themes	Median numbers Indicators
economic	4	9
environmental	6	22,5
social	3	18
governance	5	19

Even more than the number of themes, the number of indicators within each dimension shows the large variation among the ISA's from reductionist (using very few indicators to assess the system) to holistic (using many diverse indicators) (Figure 31).

- For the economic dimension 9 is the median number of indicators, ranging from only 1 to “about 150 indicators with relevance for economic sub-themes”, but almost half of the ISA methods uses 10 or less indicators.
- For the environmental dimension the number of indicators ranges from 5 to 200, 1/4th of the ISAs uses ≤ 10 indicators, while 1/3rd uses > 40 indicators, with a median of 22.5.

- For the social dimension the variation in numbers of indicators between the ISAs is even larger: they range from 2 to 300. The very large numbers are the exceptions though: only 1/5th of the ISAs uses > 40 indicators.
- For the governance dimension out of the 7 ISAs that provided numbers, 3 use only 1-5 indicators, while 1 respondent reports using 150 indicators.

Only 2 respondents claim that their ISA represents the agricultural system in a reductionist way (see section 4.1.1.8). The share of ISAs using only 1-5 indicators to describe a sustainability dimension is: economic 24 %, environmental 7 %, social 16 %. So indeed, there seem to be very few reductionist ISAs in our survey. As the economic dimension is handled in a more reductionist way than the environmental dimension, many ISA methods indeed comprise a "combination" of representations.

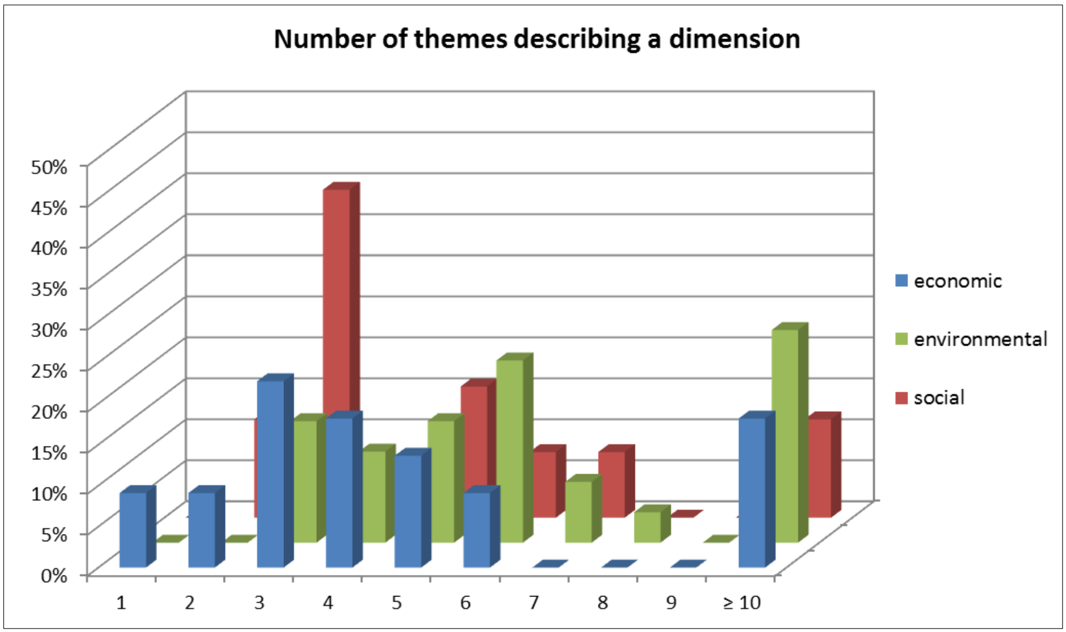


Figure 30. Distribution of the number of themes describing the main dimensions in the ISAs.

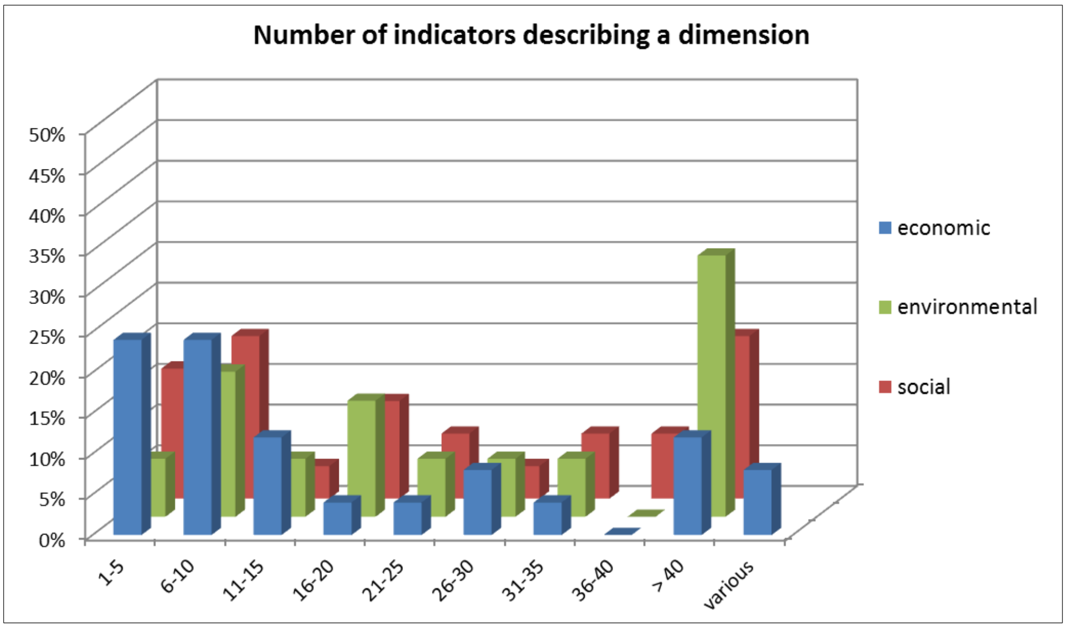


Figure 31. Distribution of the number of indicators describing the main dimensions in the ISAs.

4.1.3.4 *Reliability and validation*

The reliability of data input for the indicators in each dimension is shown in Figure 32. The first thing that stands out here is the large non-response rate. What might be the cause? Do respondents feel this is sensitive information and thus feel reluctant to answer the question? Have we insufficiently explained what is meant by “reliability”?

None of the respondents indicate that the data input for the economic indicators is doubtful. One does so for the environmental and 5 for the social indicators in their ISA method. The share of respondents stating that data input for all indicators is reliable is also smallest for the social dimension. A number of potential causes can be imagined:

- Could this be related to the data source?
- Is it due to the more qualitative nature of the social indicators?
- If so, are the qualitative indicators used less reliable *in se*? Or do the ISA method developers/users feel less comfortable with qualitative indicators?
- If the respondent is not the developer of the ISA method, he/she simply might not know how reliable the data input is.

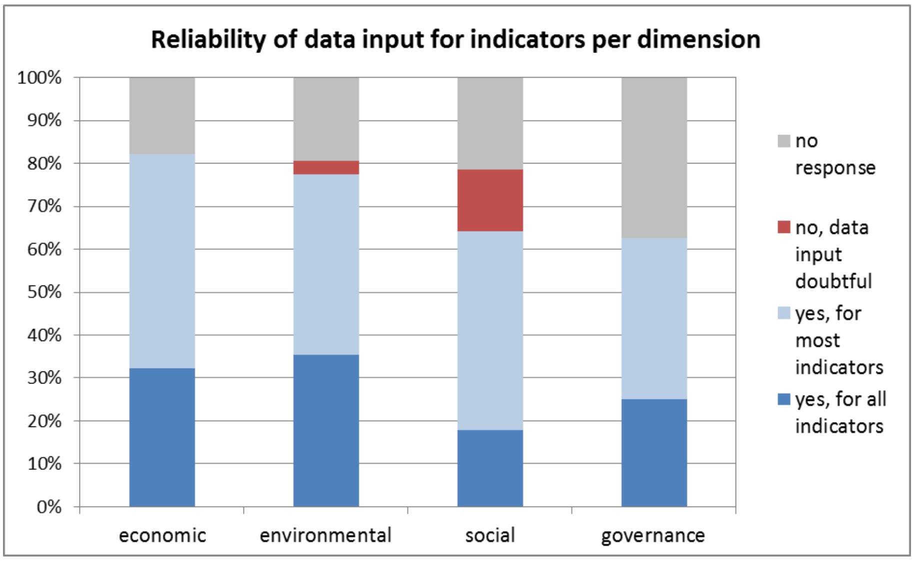


Figure 32. Distribution of the reliability of data input for the indicators per dimension.

For the validation of the indicator calculation method we find equally large non-response rates, become larger going from economic, over environmental, to social and to governance indicators. About 2/3rd of the respondents state that the economic and environmental indicators in their ISA methods are validated. Only about 1/3rd does so for the social and governance indicators. Similar considerations as before can be made here.

Some of the validation methods mentioned:

- resource data validated in previous studies,
- comparison with other methods,
- peer review,
- checking results with experts (e.g. accountants in case of the economic indicators),
- participative group validation

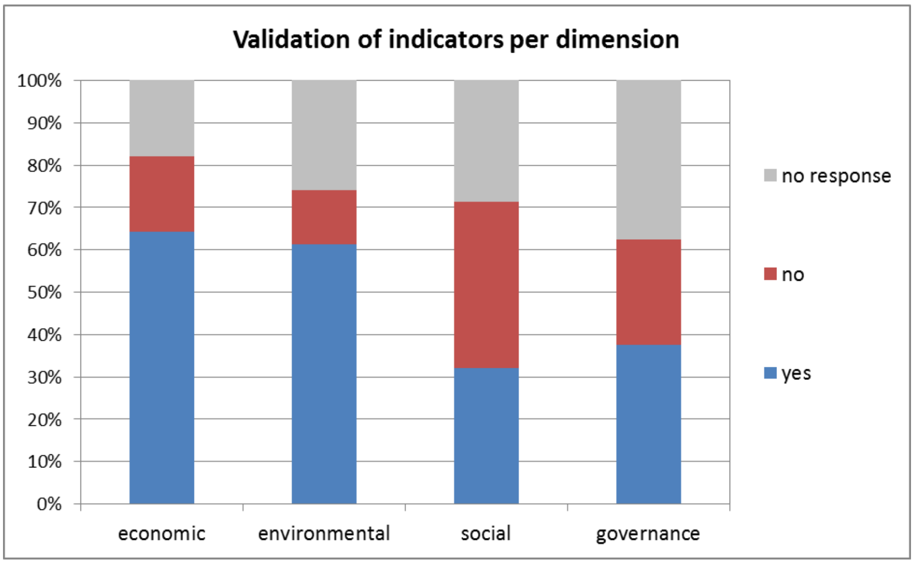


Figure 33. Distribution of the validation of the data calculation method for the indicators per dimension.

4.1.3.5 Indicator scoring

Figure 34 shows the distribution of how the how the indicators are scored in each of the main sustainability dimensions. Several respondents report more than one scoring system for their ISA, i.e. a mix of scoring systems within one dimension.

For the economic and environmental indicators, scoring systems based on benchmarks are clearly the most used (ticked by respectively 75 and 85 % of the respondents). Expert based monitoring becomes more important for the social and especially for the governance indicators.

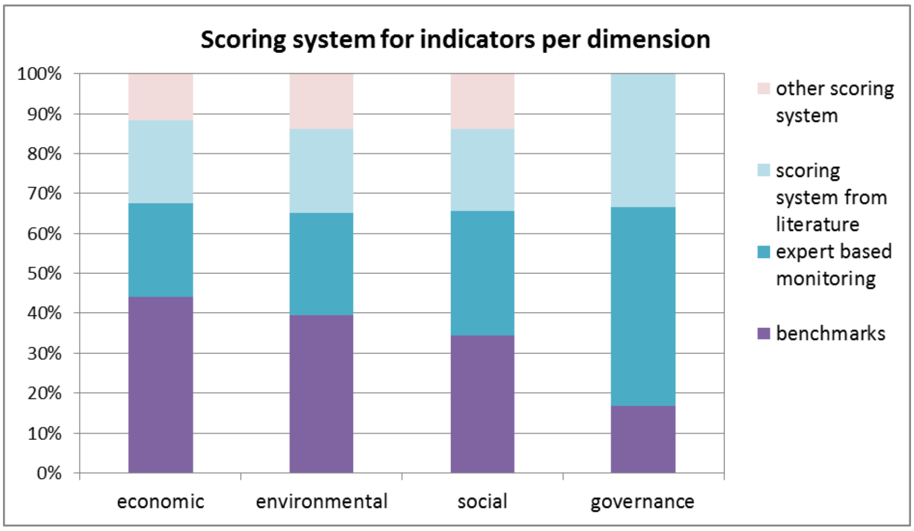


Figure 34. Distribution of scoring systems used in the ISAs per dimension.

Some examples of the specifications given for the methods used:

- Benchmarking: government regulations/legal guidelines, regionals databases (e.g. FADN for economic indicators), comparison with similar enterprises, highest x % = 100 – lowest x % = 0
- Expert based monitoring: experts scoring practices, scoring by a group of experts
- Scoring systems from literature: reference values from literature, unsustainable thresholds from literature, results from previous surveys.

4.2 Relations between the general assessment characteristics

4.2.1 Correlations between the assessment characteristics

In our survey, we asked for very few numeric answers, except for the numbers of themes and indicators per sustainability dimension. For most questions on the assessment characteristics a number of options were given (often including "other", with the possibility to specify), often with the possibility to tick several answers. Many respondents employed these possibilities, indicating for instance multiple primary purposes for their assessment methods. This enabled us to summarise the categorical variables, simply by counting the numbers of categories ticked. The numbers of attributes of each assessment characteristic gave continuous variables, for which correlations were calculated.

Especially the general assessment characteristics proved to be quite well correlated (Table 9). The number of primary purposes (intended functions), the number of dimensions considered in the ISA, the number of assessment levels (spatial scales), the number of applying users (carrying out the assessment), the number of end-users (using the assessment results), the number of methods used for data collection, and the number of ISA components for which background documents are available, all proved positively correlated. The correlations are not very strong, but many of them are statistically (very) significant. This means that ISA methods with more purposes usually also consider more dimensions, are assessed on more assessment levels, are applied by more users, can serve more end-users and have more types of background documents available.

Table 9. Correlations between the numbers of attributes of the general assessment characteristics

		N° dimensions considered	N° primary purposes	N° assessment levels	N° applying users	N° end users	N° methods data collection	N° types background documents	N° phases with stakeholder involvement	Implementation
Q15	**N° dimensions considered**	1	0,407 0,012	0,475 0,003	0,366 0,026	0,480 0,003	0,070 0,683	0,257 0,125	0,148 0,384	0,258 0,141
Q18	**N° primary purposes**	0,407 0,012	1	0,419 0,010	0,363 0,027	0,291 0,081	0,041 0,810	0,279 0,095	0,251 0,133	0,355 0,040
Q19	**N° assessment levels**	0,475 0,003	0,419 0,010	1	0,303 0,068	0,442 0,006	0,101 0,553	0,303 0,068	0,115 0,498	-0,012 0,944
Q22	**N° applying users**	0,366 0,026	0,363 0,027	0,303 0,068	1	0,545 0,001	0,309 0,063	0,274 0,101	0,320 0,053	0,131 0,460
Q23	**N° end users**	0,480 0,003	0,291 0,081	0,442 0,006	0,545 0,001	1	0,312 0,060	0,427 0,008	0,465 0,004	-0,139 0,433
Q25	**N° methods data collection**	0,070 0,683	0,041 0,810	0,101 0,553	0,309 0,063	0,312 0,060	1	-0,072 0,671	0,241 0,151	-0,200 0,257
Q30	**N° types back-ground docs**	0,257 0,125	0,279 0,095	0,303 0,068	0,274 0,101	0,427 0,008	-0,072 0,671	1	0,248 0,139	0,300 0,085
T_ SH	**N° phases with stakeholders**	0,148 0,384	0,251 0,133	0,115 0,498	0,320 0,053	0,465 0,004	0,241 0,151	0,248 0,139	1	0,102 0,565

Pearson Correlation Coefficients and Probability > |r| under H_0: Rho=0. Statistically significant correlations are highlighted in blue for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

The time needed for data collection, however, is not correlated to either of the above characteristics. Given the diverse methods for data collection discussed in sections 4.1.1.11 and 4.1.1.12 this should come as no surprise.

A similar analysis was made for the number of ISA development phases involving stakeholder participation (Table 9) and the number of stakeholder categories involved in each of the six phases of ISA development (not shown). The number of phases with stakeholder involvement shows a significant positive correlation with the numbers of applying users and end-users. Stakeholder participation throughout the development process is thus linked with more types of users. The correlation evidently does not show the causality of this relation. Developing an ISA method that from the beginning envisages multiple users, might require more stakeholder involvement or inversely, if stakeholders are involved in more phases of the development process, they might be more willing to implement the ISA, as was suggested by several authors (Diez and McIntosh, 2009; Röling, 2009; Binder *et al*., 2010; De Mey *et al*., 2011; Cerf, 2012; Sieber *et al*., 2012; Prost *et al*., 2012; Triste *et al*., 2014). However, the actual implementation of the ISA methods (yes/no) could not be linked with the number of applying or end-users, nor with stakeholder involvement (see section 4.2.2.4).

We did find a correlation between the number of phases involving stakeholder participation and the number of environmental and social themes in the ISA method: a negative one (- 0.573 and – 0.559 respectively). This could indicate that more frequent stakeholder involvement might help to restrain the number of themes being assessed or maybe just to cluster indicators in a smaller numbers of themes. The number of indicators was not significantly correlated.

Also, one could imagine that more stakeholders with different backgrounds involved in the early phases of ISA development, might result in more diverse ISA purposes or themes taken into consideration. This assumption, however, is not confirmed by the correlation analysis. No significant correlations were found between de the numbers of stakeholder categories and either of the general ISA characteristics, nor with the numbers of themes/indicators. The only exception is stakeholder involvement in phase 5, concerning the applicability of the assessment results (the process of getting the generated knowledge ready for utilization in practice). A 0.60 (very significant) correlation was found between the number of stakeholder categories in phase 5 and the number of applying users. Moreover, the number of end-users, the number of assessment levels and the number of background documents all were correlated with stakeholder involvement in phase 5 (0.49, 0.35 and 0.43 respectively). This emphasises the importance of diverse stakeholder involvement in getting the ISA ready-for-use in practice.

Finally, the numbers of themes and indicators in each of the sustainability dimensions and the total number of themes and indicators in the ISA methods were analysed. Apart from the already mentioned relation with the frequency of stakeholder participation, the numbers of themes and indicators in each of the dimensions and in total are only mutually correlated, indicating that an ISA with many indicators in one dimension, also has many indicators in the others, resulting in large total numbers of indicators. Only the number of economic themes shows a 0.80 correlation with the number of assessment levels and a 0.54 correlation with the number of primary purposes (both very significant). Indeed the more narrow purposed ISA methods often have few economic themes and indicators, whereas almost all ISAs cover a large range of environmental themes.

4.2.2 Associations between the categorical variables

Most of the questions in the survey were provided with categorical answers, mostly nominal categories (e.g. the types of stakeholders involved), sometimes ordinal (e.g. the time needed for data collection) or even dichotomous (e.g. Is the assessment being implemented? Yes/no). For the questions with nominal categories, multiple answers were possible, i.e. multiple categories could be ticked. For further analysis all the categories thus needed to be converted to dichotomous variables (indicating that a specific options is used in the ISA at hand yes or no). This left us with a multitude of dichotomous and some ordinal variables.

Such variables cannot be analysed by the customary Pearson or Spearman correlations, as they are evidently not normally distributed and/or the intervals between the ordinal categories cannot be assumed equal. Two measures exist to determine association between dichotomous variables, the phi-coefficient and the tetrachoric correlation coefficient (or the polychoric correlation in the case of > 2 categories). Both measures have been rigorously defined, with specific assumptions.

- The tetrachoric correlation rests on the assumption of underlying normally distributed variables (Pearson, 1900, cited by Bonnet & Price, 2005).
- The phi-coefficient is the linear correlation between underlying inherent dichotomous distributions (Chedzoy, 2006).

In our case, the phi-coefficient should thus be used. However, Ekström (2011) ascertained a continuous bijection between the phi-coefficient and the tetrachoric correlation coefficient, as a result of which the phi-coefficient can be computed using the assumptions of the tetrachoric correlation coefficient construction and *vice versa*. Because both measures of association can be computed under either assumption, and since differences in values resulting from making the erroneous assumption will in general not appreciably change the conclusions of the association analysis, the choice of measure of association is not crucial. Whether the underlying joint distribution is normal or discrete does not have a substantial impact on the conclusions of the association analysis. Hence, the choice between the two measures of association should in principle only be a matter of preference (Ekström, 2011).

In SAS 9.4 phi analysis needs to be performed in pairs of variables, whereas polychoric and tetrachoric analysis can conveniently be performed for many variables at once (while the software automatically compares pairs of variables). We therefore chose to analyse the association between the dichotomous ISA characteristics by calculating tetrachoric correlations, using the polychor option in SAS's CORR procedure.

4.2.2.1 Associations with the primary purpose of the assessment

Table 10 shows how some of the general assessment characteristics are associated with the primary purpose of the assessment. Concerning the scope of the assessment, for only one dimension significant associations are found. The presence of an economic dimension in the ISA is strongly associated with the communication and a farm development purposes. On the contrary, if the purpose is certification, this is associated with the absence of an economic dimension.

For the societal perspective on sustainability no significant associations with any of the primary purposes was found. The farm perspective is obviously positively associated with the farm development purpose, but negatively with the communication purpose.

Table 10. Associations of some general survey characteristics with the primary purpose of the assessment

			Primary purpose									
			reporting		communi-cation		farm development		research		certification	
		N	Corre-lation	Pr > ChiSq	Corre-lation	Pr > ChiSq	Corre-lation	Pr > ChiSq	Corre-lation	Pr > ChiSq	Corre-lation	Pr > ChiSq
Economic dimension		37	-0,068	0,834	0,976	0,041	0,669	0,018	0,269	0,423	-0,576	0,090
Perspective on sustain-ability	**societal**	37	-0,024	0,941	0,307	0,312	-0,289	0,325	0,250	0,410	-0,965	0,181
	farm	37	0,048	0,860	-0,485	0,073	0,432	0,089	0,048	0,860	0,099	0,774
Level of assessment: spatial scale	**field**	37	0,160	0,593	-0,981	0,016	0,058	0,843	0,394	0,169	-0,967	0,149
	farm	37	0,061	0,831	0,238	0,419	0,481	0,064	-0,548	0,036	0,973	0,082
	industry	37	0,999	0,001	0,357	0,298	0,982	0,034	0,310	0,367	-0,973	0,324
	chain	37	0,689	0,010	0,307	0,312	0,501	0,096	0,487	0,090	-0,965	0,181
	nat./regional	37	-0,185	0,597	-0,139	0,696	-0,592	0,052	0,475	0,128	-0,966	0,267
	landscape	37	-0,976	0,050	-0,139	0,696	-0,592	0,052	0,727	0,011	-0,966	0,267
	other	37	0,352	0,252	-0,976	0,041	-0,158	0,609	0,068	0,834	-0,964	0,220
Applying user	**farmer**	37	0,426	0,103	-0,068	0,808	0,432	0,089	-0,732	0,004	0,099	0,774
	advisor	37	0,093	0,741	-0,056	0,847	0,363	0,174	-0,352	0,213	-0,975	0,067
	researcher	37	-0,263	0,328	0,231	0,400	-0,123	0,638	0,500	0,054	-0,988	0,016
	civil servant	37	0,175	0,598	0,521	0,093	0,348	0,295	0,175	0,598	-0,966	0,267
	auditor	37	0,160	0,593	0,221	0,462	0,058	0,843	-0,103	0,738	0,999	0,000
	others	37	0,080	0,787	-0,116	0,705	-0,291	0,295	0,513	0,059	0,012	0,974
End-user	**indiv. farmer**	37	0,455	0,133	0,116	0,705	0,670	0,009	-0,687	0,007	0,969	0,123
	discuss. group	37	-0,127	0,641	-0,028	0,920	0,455	0,068	0,069	0,800	-0,991	0,012
	advisors	37	0,301	0,262	0,196	0,478	0,371	0,151	-0,093	0,736	-0,982	0,034
	researchers	37	0,207	0,444	0,328	0,230	0,019	0,942	0,586	0,023	-0,422	0,211
	policy makers	37	0,108	0,693	-0,225	0,421	-0,164	0,531	0,643	0,009	-0,982	0,034
	others	37	0,451	0,086	0,177	0,521	-0,392	0,121	-0,500	0,054	0,352	0,306
Aggregation of indicators		37	0,125	0,660	0,293	0,312	-0,553	0,033	0,352	0,213	-0,265	0,440
Weighted aggregation		22	-0,389	0,272	0,082	0,822	0,159	0,647	0,535	0,124	-0,986	0,122
Implementation of ISA		34	0,078	0,834	0,974	0,083	0,179	0,611	0,976	0,066	0,967	0,301

Tetrachoric Correlation Coefficients and Probability > Chi Square under H_0: Rho=0. Statistically significant correlations are highlighted in blue for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

The associations for the assessment levels point to different spatial scales being assessed for different purposes.

- The reporting purpose is strongly associated with assessment on the industry wide and the chain levels, but the landscape level is absent.
- ISAs with a communication purpose do not use field level assessment (negative association).
- If the purpose is farm development, assessment can be performed at farm, industry or chain level, but not at landscape, regional or national level.
- The ISAs in our survey with a research purpose focus on landscape or chain level assessments, but not on the farm level (association –0.55).
- ISAs with a certification purpose, in contrast, are strongly associated with farm level assessment (association +0.97).

The applying user of ISA methods with research purpose clearly is not the farmer (-0.73), but a researcher or another. Certification ISAs are exclusively applied by an auditor (0.999), all other potential applying users are absent, as the associations for them are equally strong, but negative.

The end users are also differentiated by purpose:

- ISAs with farm development purpose are obviously used by farmers, either individually (0.67) or in discussion groups (0.46).
- At the same time, the research purpose is absent if end-users are individual farmers. ISAs with research purpose are obviously used by researchers (0.59), but also policy makers are strongly associated end-users (0.64).
- The certification purpose is clearly absent with all end-users, except for the individual farmer (all others have a negative association).
- The reporting and communication purposes are not significantly associated with any end-user.

Finally, an affirmative answer to the question whether the assessment is being implemented is strongly associated with either a communication or a research purpose.

The stakeholder participation table is not shown as it does not contain many significant associations. Two observations though:

- The communication purpose is strongly associated with stakeholder participation in phase 5 (the process of getting the generated knowledge ready for utilization in practice). The certification purpose is strongly associated with participation in phases 5 and 6 (follow-up: reporting results, developing management advice, monitoring of indicators over time).
- The farm development purpose mostly shows negative associations with stakeholder participation.

4.2.2.2 Associations with the end-user of the assessment

Table 11 shows the associations between some of the general assessment characteristics and the end-users named in the survey. Regardless of the end-user of the ISA methods the environmental dimension is most prevalent (tetrachoric correlation coefficient > 0.98 for types of all end-users). The economic dimension is most likely to be assessed if the end-users are policy makers, researchers or farmers in discussion groups. No significant association is found between individual farmers as end-users and the presence of an economic dimension in the ISAs, probably because this dimension was significantly absent from certification systems and the individual farmer is an important end-user for those (Table 10). The social dimension is strongly associated with policy makers. If the end-user is an extension worker (advisor) the social dimension rather seems absent (the only negative association, although not significant).

The societal perspective is most present when end-users are policy makers or researchers. For policy makers the farm perspective is significantly absent.

For individual farmers the associated assessment level is the farm. This is probably linked with the certification tools in the survey that have the farm as assessment level. The larger spatial levels, landscape, or national/regional are not used for individual farmer’s assessments. These level are rather associated with policy makers, who are also strongly associated with the industry wide level and with the chain level. They are not concerned with the farm or field assessment levels. Rather surprisingly, the extension worker (advisor) as end-user is strongly associated with the field and the whole industry assessment levels, not with the farm level.

The applying users associated with the end-users are usually themselves (or civil servants associated with policy makers). Furthermore, civil servants as end-users are strongly linked to extension as end-user. Both civil servants and extension workers (advisors) are strongly associated with end-users being farmers in discussion groups. Individual farmer end-users are most strongly associated with auditors as applying users, which is linked to the certification goal and to self-assessment as the method for data collection.

Table 11. Associations of some general survey characteristics with the end user of the assessment

			End user: Who is using the results of the assessment?									
			individual farmer		farmer in discussion groups		extension workers		policy makers		research	
		N	Correlation	Pr > ChiSq	Correlation	Pr > ChiSq	Correlation	Pr > ChiSq	Correlation	Pr > ChiSq	Correlation	Pr > ChiSq
Assessment scope: dimensions considered	economic	37	0,179	0,585	0,571	0,055	0,125	0,692	0,987	0,008	0,604	0,039
	environmental	37	0,999	0,014	0,992	0,083	0,982	0,142	0,982	0,142	0,995	0,072
	social	37	0,012	0,974	0,020	0,954	-0,491	0,138	0,982	0,034	0,422	0,211
	governmental	37	0,172	0,621	0,538	0,075	0,422	0,158	0,669	0,018	0,991	0,004
Perspective on sustainability	societal	37	-0,092	0,774	0,353	0,231	0,289	0,325	0,520	0,065	0,571	0,050
	farm	37	0,421	0,132	0,303	0,234	-0,086	0,742	-0,432	0,089	-0,281	0,272
Level of assessment: spatial scale	field	37	0,304	0,353	0,435	0,123	0,601	0,025	0,398	0,156	0,629	0,024
	farm	37	0,687	0,007	0,127	0,641	0,093	0,736	-0,108	0,693	-0,011	0,969
	industry	37	0,969	0,123	0,352	0,306	0,999	0,005	0,999	0,005	0,986	0,021
	chain	37	-0,092	0,774	0,102	0,733	0,289	0,325	0,520	0,065	0,571	0,050
	nat./regional	37	-0,570	0,064	-0,177	0,584	0,301	0,345	0,999	0,001	0,989	0,009
	landscape	37	-0,570	0,064	0,135	0,676	-0,009	0,979	0,592	0,052	0,421	0,194
System representation	reductionistic	37	-0,343	0,419	-0,017	0,969	-0,982	0,142	0,118	0,781	0,986	0,110
	holistic	37	-0,507	0,062	0,041	0,873	-0,123	0,638	-0,123	0,638	-0,215	0,401
	combination	37	0,646	0,017	-0,037	0,886	0,264	0,306	0,091	0,729	0,061	0,815
Applying user	farmer	37	0,646	0,017	0,135	0,603	-0,086	0,742	-0,432	0,089	-0,442	0,076
	advisor	37	0,498	0,093	0,679	0,005	0,923	<.0001	0,026	0,923	0,285	0,282
	researcher	37	-0,549	0,040	0,128	0,618	0,455	0,068	0,604	0,012	0,668	0,004
	civil servant	37	-0,281	0,402	0,991	0,007	0,999	0,001	0,592	0,052	0,421	0,194
	auditor	37	0,979	0,024	-0,025	0,931	-0,058	0,843	0,177	0,541	0,158	0,586
	others	37	0,053	0,865	0,082	0,772	-0,376	0,186	-0,146	0,610	0,465	0,092
Method for data collection	interview	37	0,590	0,025	0,723	0,001	0,641	0,007	0,328	0,201	0,657	0,005
	audit	37	0,976	0,036	-0,395	0,175	0,042	0,890	-0,501	0,096	-0,437	0,130
	self-assessment	37	0,549	0,040	0,041	0,873	-0,123	0,638	-0,293	0,253	-0,378	0,132
	other	37	-0,507	0,062	-0,294	0,246	-0,293	0,253	0,548	0,025	0,291	0,252
Aggregation of indicators		37	-0,228	0,441	0,217	0,414	0,363	0,174	0,737	0,003	0,452	0,078
Weighted aggregation		22	-0,455	0,207	0,045	0,899	0,159	0,647	0,794	0,007	0,461	0,170
Implementation of ISA		34	-0,969	0,129	-0,299	0,400	-0,996	0,007	0,258	0,472	0,088	0,801

Tetrachoric Correlation Coefficients and Probability > Chi Square under H_0: Rho=0. Statistically significant correlations are highlighted in blue for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

Aggregation of indicators and weighted aggregation proved mainly done for policy makers (tetrachoric correlation coefficients 0.74 and 0.79 respectively). No significant association with other end-users was found.

4.2.2.3 Associations with the transparency of the assessment methods

In the survey we tried to obtain information on the transparency of the assessment methods by asking about which aspects of the assessment background documentation is available. Table 12 shows the associations between some general ISA characteristics and the types of documentation available. The availability of documents or reports is clearly associated with research as the primary purpose of the ISA. All types of documents have positive polychoric correlation coefficients with the research purpose and most of them are significant. For all other purposes no significant association with documentation was found.

The field assessment level has some very strong associations with documentation availability, as has the chain level. By contrast the farm level has some very strong negative associations, indicating the absence of documents and reports on many aspects of the assessment in ISAs that have the farm as assessment level.

Also when the individual farmer is the applying or the end-user associations with documentation are mostly negative, hence documents or reports absent. As could be expected from the strong association with the research purpose, ISAs for researchers are the best documented (most aspects are covered), followed by those for policy makers.

A strong positive association is found between indicator aggregation and documentation availability. If indicators are aggregated, documents or reports on content, purpose and methodology are available (significant tetrachoric correlations coefficients of 0.55, 0.99 and 0.77 respectively). Also background documents on the aggregation itself are usually available for those ISAs (very significant association of 0.83, not shown in Table 12).

Implementation of the ISA has a strong association with the methodology being documented. However, this is only a significantly positive association if implementation is on project basis. For implementation in form of certification, documentation is absent (negative association), as it also seems to be for ISAs implemented by farmers.

4.2.2.4 Associations with implementation

A very important question in the survey was "Is the assessment being implemented?" The relations with a positive or negative answer to this question were studied. Few significant relations were actually found. Possibly because out of the 34 respondents who answered the question, only 4 stated their ISA is not being implemented. The variation in the sample might thus be too small to find much statistical significance. The only significant correlations found with the continuous variables were not very strong: 0.30 for the number subjects for which background documents are available, 0.35 for the number of purposes in the ISA. The two by two comparison of the dichotomous variables did show strong association between the communication and research purposes and the implementation of the ISA (as seen in Table 10 under section 4.2.2.1). A stricking, but hard to explain association is the negative one with extension workers as end-users of the ISA (-0.996, with a 0.007 significance level, Table 11 under section 4.2.2.2).

Table 12. Associations of some general survey characteristics with the transparency of the assessment

			Transparency: Are documents or reports available									
			content		purpose		methodology		indicator scoring		interpretation of results	
		N	Corr	Pr > χ^2	Corr	Pr > χ^2	Corr	Pr > χ^2	Corr	Pr > χ^2	Corr	Pr > χ^2
Primary purpose	reporting	37	0,10	0,74	-0,18	0,60	-0,07	0,83	-0,23	0,41	-0,30	0,26
	communic.	37	0,05	0,88	0,14	0,70	0,22	0,52	0,18	0,55	0,01	0,97
	farm develop	37	0,18	0,54	-0,35	0,30	-0,43	0,17	0,39	0,14	-0,19	0,46
	research	37	0,10	0,74	0,98	0,05	0,98	0,03	0,24	0,42	0,70	0,01
	certification	37	-0,07	0,86	0,97	0,27	0,96	0,22	-0,36	0,30	-0,49	0,14
Level of assess-ment: spatial scale	field	37	0,98	0,03	0,97	0,10	0,97	0,07	0,35	0,27	0,30	0,30
	farm	37	-0,40	0,20	-0,98	0,05	-0,98	0,03	-0,24	0,42	-0,30	0,28
	industry	37	0,97	0,15	0,97	0,27	0,96	0,22	0,97	0,10	0,24	0,49
	chain	37	0,19	0,59	0,97	0,13	0,97	0,10	0,98	0,03	0,22	0,47
	nat./regional	37	0,03	0,92	0,96	0,21	0,96	0,17	0,14	0,70	0,35	0,30
	landscape	37	0,97	0,10	0,96	0,21	0,96	0,17	0,14	0,70	0,35	0,30
Applying user	farmer	37	-0,13	0,66	-0,56	0,07	-0,64	0,03	-0,14	0,61	-0,43	0,09
	advisor	37	-0,10	0,73	0,23	0,51	-0,30	0,33	0,55	0,06	-0,03	0,92
	researcher	37	-0,02	0,93	0,46	0,15	0,99	0,00	0,57	0,03	0,39	0,12
	civil servant	37	0,97	0,10	0,96	0,21	0,96	0,17	0,97	0,06	0,01	0,98
	auditor	37	-0,08	0,80	0,97	0,10	0,97	0,07	0,05	0,88	-0,18	0,54
End-user	ind. farmer	37	0,02	0,96	-0,97	0,08	-0,97	0,05	-0,12	0,71	-0,38	0,19
	discuss. group	37	0,25	0,37	0,18	0,58	0,02	0,94	0,78	0,00	0,46	0,07
	advisors	37	0,30	0,30	0,35	0,30	-0,16	0,61	0,66	0,01	0,19	0,46
	researchers	37	0,08	0,80	0,52	0,09	0,60	0,04	0,48	0,07	0,66	0,01
	policy makers	37	0,30	0,30	0,35	0,30	0,99	0,01	0,44	0,11	0,54	0,03
Aggregation of indic.		37	0,55	0,05	1,00	0,00	0,76	0,00	0,37	0,17	0,40	0,13
Weighted aggregation		22	-0,98	0,11	.	.	-0,98	0,37	0,03	0,95	-0,37	0,33
Implementation of ISA		34	0,43	0,22	0,32	0,43	0,87	0,00	0,03	0,94	0,18	0,61
Implemen-tation type	project	30	0,22	0,53	0,17	0,68	1,00	0,01	0,67	0,02	0,82	0,00
	commercial	30	0,35	0,31	0,98	0,11	-0,22	0,61	0,10	0,76	-0,08	0,79
	certification	30	-0,38	0,25	-0,05	0,90	-0,99	0,02	-0,52	0,08	-0,61	0,03
	by farmers	30	-0,06	0,85	-0,99	0,03	-0,99	0,07	-0,46	0,13	0,03	0,92

Tetrachoric Correlation Coefficients and Probability > Chi Square under H_0: Rho=0. Statistically significant correlations are highlighted in blue for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

The respondents who answered "yes" to the implementation question, were presented with a follow-up question: "How is the assessment implemented? On project basis, used commercially, certification, used by farmers, or otherwise?" Table 13 shows the association of other general ISA characteristics with the different types of implementation.

Implementation on project basis is associated with

- "other" purposes than the ones listed in the survey. "consultancy", "teaching", "impact assessment" and "policy support" were named as alternative purposes. ISAs implemented on project basis obviously are not intended for certification (association -0.76);
- various applying users: extension worker, researcher, civil servant, others (except auditors);
- researchers or policy makers as end-users;
- a wide availability of background documents.

Table 13. Associations of some general survey characteristics with different types of implementation

		N	Implementation = yes Correlation	Implementation = yes Pr > ChiSq	Implementation: project basis Correlation	Implementation: project basis Pr > ChiSq	Implementation: commercially Correlation	Implementation: commercially Pr > ChiSq	Implementation: certification Correlation	Implementation: certification Pr > ChiSq	Implementation: used by farmers Correlation	Implementation: used by farmers Pr > ChiSq
Primary purpose	reporting	34	0,078	0,834	-0,267	0,407	0,681	0,012	0,082	0,795	0,420	0,149
	communication	34	0,974	0,083	0,101	0,758	0,397	0,176	0,000	1,000	0,302	0,300
	farm development	34	0,179	0,611	-0,167	0,607	0,411	0,169	0,077	0,803	0,251	0,387
	research	34	0,976	0,066	0,479	0,138	-0,655	0,023	-0,603	0,043	-0,463	0,100
	certification	34	0,967	0,301	-0,758	0,016	0,267	0,459	0,999	0,001	0,052	0,886
	other	34	0,172	0,639	0,990	0,006	0,524	0,062	0,175	0,565	0,191	0,510
Level of assessment: spatial scale	field	34	-0,028	0,942	0,980	0,038	-0,101	0,758	-0,370	0,275	-0,348	0,266
	farm	34	-0,971	0,104	-0,370	0,275	0,553	0,072	0,990	0,005	0,520	0,072
	industry	34	0,967	0,301	-0,033	0,933	0,616	0,065	0,325	0,366	0,436	0,216
	chain	34	0,966	0,160	-0,126	0,713	0,456	0,136	-0,032	0,925	-0,073	0,817
	nat./regional	34	-0,233	0,562	0,970	0,129	-0,147	0,698	-0,976	0,078	0,052	0,886
	landscape	34	-0,233	0,562	0,970	0,129	-0,978	0,060	-0,976	0,078	-0,345	0,339
	other	34	0,967	0,301	0,970	0,129	0,267	0,459	-0,092	0,812	0,995	0,009
System representation	reductionist	34	0,923	0,472	0,971	0,293	-0,974	0,193	-0,973	0,223	-0,985	0,104
	holistic	34	0,378	0,277	0,199	0,526	-0,302	0,300	-0,191	0,523	0,112	0,695
	combination	34	-0,455	0,182	-0,325	0,294	0,449	0,115	0,335	0,258	0,087	0,765
Applying user	farmer	34	-0,088	0,801	-0,262	0,401	0,577	0,036	0,485	0,091	0,400	0,151
	advisor	34	-0,570	0,083	0,985	0,016	0,254	0,403	0,082	0,795	-0,048	0,873
	researcher	34	0,378	0,277	0,997	0,000	-0,077	0,796	-0,420	0,149	-0,098	0,732
	civil servant	34	0,964	0,243	0,973	0,086	0,119	0,732	0,183	0,601	0,546	0,094
	auditor	34	0,969	0,129	-0,597	0,046	0,578	0,045	0,937	<.0001	0,317	0,294
	others	34	0,969	0,129	0,983	0,024	-0,190	0,553	-0,119	0,716	-0,187	0,542
End-user	ind. farmer	34	-0,969	0,129	-0,309	0,375	0,493	0,122	0,988	0,009	0,187	0,542
	discussion group	34	-0,299	0,400	0,460	0,130	-0,302	0,300	-0,191	0,523	0,112	0,695
	advisors	34	-0,996	0,007	0,479	0,138	0,081	0,789	-0,338	0,271	-0,030	0,919
	researchers	34	0,088	0,801	0,742	0,008	0,078	0,794	-0,263	0,378	0,014	0,961
	policy makers	34	0,258	0,472	0,574	0,063	-0,078	0,794	-0,220	0,466	0,197	0,490
	others	34	0,378	0,277	-0,348	0,266	0,782	0,003	0,520	0,072	0,511	0,060
Method for data collection	interview	34	-0,983	0,032	0,460	0,130	-0,077	0,796	0,048	0,873	0,112	0,695
	audit	34	-0,491	0,158	-0,850	0,002	0,119	0,732	0,762	0,010	-0,112	0,743
	self-assessment	34	0,000	1,000	-0,404	0,190	0,646	0,017	0,575	0,042	0,590	0,026
	other	34	0,378	0,277	0,460	0,130	-0,302	0,300	-0,191	0,523	-0,098	0,732
Aggregation of indicators		34	0,610	0,061	0,345	0,284	0,190	0,553	-0,170	0,594	-0,317	0,294
Weighted aggregation		21	-0,983	0,405	0,299	0,531	-0,550	0,112	-0,217	0,580	-0,108	0,769

Tetrachoric Correlation Coefficients and Probability > Chi Square under H_0: Rho=0. Statistically significant correlations are highlighted in blue for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

Commercial implementation is associated with

- reporting being the purpose of the assessment (+ 0.68), but not research (- 0.66);
- assessment at the farm or industry-wide level, but not at the landscape level (- 0,98);
- “other” end-users, “businesses, investors and banks” were named, and several times “operators in the supply chain: food companies, retail, … up to consumers”.

Implementation for certification is associated with:

- the certification purpose obviously, but not with research, i.e. the opposite of implementation on project basis;
- the farm as assessment level, not the landscape or the region/nation;
- auditors as applying users (in almost all cases) and sometimes farmers;
- farmers as end-users, as well as others (the buyers).

Implementation “used by farmers” is associated with:

- the farm as assessment level
- civil servants as applying users;
- “other” users, as for most of the commercial or certification ISAs also “used by farmers” was ticked as implementation type;

Surprisingly the implementation “used by farmers” does NOT show association

- with “farm development” as a primary purpose;
- nor with the farmer as end-user of the ISA.

4.2.3 Stakeholder participation in relation to other assessment characteristics

4.2.3.1 Purpose of the assessment

Few associations were found between the purpose of the assessment and stakeholder participation and even less meaningful ones. The fact that stakeholders were involved in a certain development phase and the ISA’s purpose was only significant for 4 combinations:

- A very strong association with stakeholder participation in phase 5 (applicability of the assessment results, the process of getting the generated knowledge ready for utilization in practice) of the development process of ISAs with communication and research purposes.
- A less strong and less significant association in phase 4 (taking decisions on whether or not to aggregate indicators, to which extent and how) of developing ISAs with reporting, communication and research purposes.

Associations between purpose and stakeholder type by development phase that attract attention are

- the mostly negative associations between the farm development purpose and the different types of stakeholders. Also participation by farmers themselves for most phases shows negative association (although only significant in phase 4).
- Farmer participation is rather positively associated with the certification purpose. In phase 1 (the preparatory phase, where context, goal and challenges are defined) and phase 3 (indicator measurement: quantification of indicators and processes) the association is even very strong (> 0.97) and significant.

4.2.3.2 End user of the assessment

Table 14 shows that the end-users of ISAs are not necessarily involved in the development.

- For ISA's used by individual farmers, farmer participation is only significantly positive in phase 5 (applicability). By contrast, in phase 3 (indicator quantification) the association between the farmer as end-user and farmer participation is even strongly and significantly negative. Also for the other stakeholders the association is mostly negative.
- The situation is similar for ISA used by farmers in discussion groups.
- Extension workers and policy makers, on the other hand, are involved in most of the development phases of ISAs for which they are the end-users.
- Researchers, finally, only have significant participation in phases 4 and 6 of the development of ISAs of which they are end-users.

4.2.3.3 Transparency

The aspects content, purpose, methodology, indicator scoring, indicator aggregation and interpretation of the results of the assessment methods roughly correspond with the 6 phases in the ISA development for which we asked whether stakeholders were involved. In Table 15 the associations between stakeholder participation and documentation availability were listed, as it might be expected that stakeholder involvement in consecutive phases stimulates the ISA developers to draft documents or reports.

Looking at Table 15, however, it stands out that the associations are not as significant as might be expected. It is striking though that those significant associations found are associations between different types of background documents and all types of stakeholders, except for farmers. Farmers' participation in ISA development and the availability of documentation show negative associations in all phases. Farmer involvement in the development process thus does not seem to stimulate ISA developers to produce documentation on the ISA.

Overall, farmer involvement with assessment methods, whether as stakeholders in the development process, as applying users, as end users or with their farm as the assessment level, shows mostly negative association with the availability of documentation. It needs further research to find out whether such associations are present for all types of farm level ISAs or whether differences may be found between different types of farm level assessment methods, such as ISAs aiming at farm development or certification systems that operate on the farm level.

Table 14. Associations of stakeholder (SH) participation in the consecutive phases of the ISA development with the end user of the assessment

		N	End user: Who is using the results of the assessment?									
			individual farmer		farmer in discussion groups		extension workers		policy makers		research	
			Correlation	Pr > ChiSq	Correlation	Pr > ChiSq	Correlation	Pr > ChiSq	Correlation	Pr > ChiSq	Correlation	Pr > ChiSq
SH participation Phase 1		36	0,379	0,374	0,035	0,936	-0,999	0,056	-0,140	0,743	0,035	0,936
Type of stake-holders	**farmers**	33	0,185	0,553	-0,070	0,805	0,225	0,437	0,000	1,000	-0,070	0,805
	advisors	33	-0,065	0,833	0,060	0,829	0,452	0,093	-0,153	0,588	0,255	0,351
	researchers	33	-0,966	0,219	-0,214	0,578	0,977	0,090	0,977	0,090	0,254	0,506
	policy makers	33	-0,414	0,166	-0,235	0,386	-0,362	0,185	0,237	0,391	-0,235	0,386
	civil society	33	-0,008	0,979	0,152	0,578	-0,019	0,947	0,185	0,506	-0,041	0,881
SH participation Phase 2		36	-0,980	0,308	0,993	0,077	0,982	0,135	0,980	0,153	0,993	0,077
Type of stake-holders	**farmers**	33	0,148	0,620	-0,264	0,333	-0,012	0,966	-0,097	0,727	-0,264	0,333
	advisors	33	-0,270	0,361	0,242	0,372	0,584	0,022	0,137	0,619	0,052	0,849
	researchers	33	-0,974	0,283	-0,984	0,112	0,982	0,129	0,980	0,149	0,058	0,894
	policy makers	33	-0,452	0,120	-0,242	0,372	-0,233	0,392	0,442	0,097	-0,423	0,109
	civil society	33	-0,326	0,266	-0,035	0,898	0,124	0,653	0,215	0,435	-0,035	0,898
SH participation Phase 3		35	0,495	0,087	0,606	0,023	0,653	0,018	0,375	0,194	0,606	0,023
Type of stake-holders	**farmers**	25	-0,996	0,010	-0,662	0,023	-0,307	0,319	-0,071	0,821	0,086	0,789
	advisors	25	-0,986	0,032	0,373	0,235	0,541	0,069	-0,156	0,622	-0,167	0,608
	researchers	25	-0,964	0,290	-0,043	0,918	0,280	0,488	0,986	0,051	0,452	0,249
	policy makers	25	-0,659	0,072	-0,236	0,531	-0,033	0,930	0,497	0,170	0,201	0,609
	civil society	25	-0,724	0,030	-0,150	0,658	0,107	0,748	-0,024	0,943	0,168	0,626
SH participation Phase 4		35	0,429	0,139	0,297	0,283	0,220	0,440	0,000	1,000	0,492	0,066
Type of stake-holders	**farmers**	24	-0,140	0,713	-0,477	0,122	-0,317	0,323	-0,484	0,126	-0,342	0,286
	advisors	24	-0,070	0,855	-0,112	0,729	0,112	0,729	-0,565	0,066	-0,494	0,110
	researchers	24	-0,971	0,150	-0,416	0,252	0,416	0,252	0,989	0,019	0,709	0,028
	policy makers	24	-0,595	0,093	-0,784	0,005	-0,211	0,519	0,446	0,158	0,109	0,743
	civil society	24	-0,203	0,639	-0,536	0,138	-0,294	0,448	-0,228	0,562	0,228	0,562
SH participation Phase 5		34	0,115	0,729	0,234	0,438	0,239	0,439	0,523	0,087	0,707	0,011
Type of stake-holders	**farmers**	26	0,654	0,035	0,431	0,165	0,657	0,031	-0,351	0,264	-0,543	0,095
	advisors	26	0,000	1,000	0,579	0,044	0,903	0,000	0,000	1,000	0,130	0,680
	researchers	26	-0,983	0,036	-0,289	0,382	0,289	0,382	0,360	0,268	0,460	0,149
	policy makers	26	-0,469	0,162	-0,301	0,355	0,011	0,973	0,741	0,011	0,471	0,164
	civil society	26	-0,349	0,340	0,991	0,012	0,629	0,055	0,577	0,085	0,985	0,028
SH participation Phase 6		36	0,206	0,495	0,263	0,340	0,035	0,900	-0,024	0,933	0,058	0,836
Type of stake-holders	**farmers**	24	0,130	0,725	0,096	0,772	0,098	0,769	-0,293	0,374	-0,549	0,078
	advisors	24	-0,107	0,768	0,251	0,430	0,649	0,028	0,035	0,916	0,131	0,682
	researchers	24	-0,979	0,070	-0,249	0,474	0,170	0,630	0,450	0,203	0,634	0,051
	policy makers	24	-0,561	0,101	0,064	0,851	0,326	0,326	0,669	0,028	0,152	0,653
	civil society	24	-0,739	0,025	0,107	0,768	0,329	0,353	0,404	0,250	0,182	0,614
	other	24	0,350	0,3463	0,035	0,916	-0,211	0,519	0,179	0,588	-0,137	0,673

Tetrachoric Correlation Coefficients and Probability > Chi Square under H_0: Rho=0. Statistically significant correlations are highlighted in blue for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

Associations of end-user and stakeholder being the same type of persons are bordered in green.

Table 15. Associations of stakeholder (SH) participation in the consecutive phases of the ISA development with the transparency of the assessment

		N	Transparency: Are documents or reports available									
			content		purpose		methodology		indicator scoring		interpreta-tion results	
		N	Corr	Pr > χ^2	Corr	Pr > χ^2	Corr	Pr > χ^2	Corr	Pr > χ^2	Corr	Pr > χ^2
SH participation Phase 1		36	0,43	0,32	0,54	0,20	0,48	0,26	0,29	0,49	0,10	0,81
Type of stake-holders	farmers	33	-0,34	0,32	0,26	0,46	-0,25	0,48	0,00	1,00	0,28	0,32
	advisors	33	-0,19	0,56	0,98	0,04	-0,33	0,31	-0,11	0,72	0,30	0,27
	researchers	33	0,27	0,51	0,82	0,02	0,75	0,03	0,54	0,13	0,33	0,37
	policy makers	33	0,55	0,07	0,99	0,02	0,47	0,15	-0,37	0,20	-0,04	0,88
	civil society	33	0,16	0,61	0,28	0,44	0,99	0,01	0,19	0,51	0,19	0,50
SH participation Phase 2		36	0,43	0,32	0,54	0,20	0,48	0,26	0,29	0,49	1,00	0,06
Type of stake-holders	farmers	33	-0,47	0,14	-0,98	0,03	-0,99	0,01	-0,66	0,02	-0,30	0,27
	advisors	33	-0,31	0,32	0,36	0,31	-0,19	0,58	0,08	0,78	0,06	0,83
	researchers	33	0,46	0,29	0,59	0,17	0,52	0,23	0,31	0,48	0,14	0,75
	policy makers	33	1,00	0,00	0,40	0,25	0,51	0,12	-0,31	0,28	-0,06	0,83
	civil society	33	0,21	0,51	0,32	0,37	0,43	0,20	0,02	0,94	0,18	0,51
SH participation Phase 3		35	0,06	0,85	0,26	0,45	0,15	0,65	0,18	0,55	0,31	0,27
Type of stakeholde rs	farmers	25	0,50	0,15	0,22	0,58	-0,03	0,93	-0,36	0,29	0,35	0,27
	advisors	25	0,00	1,00	1,00	0,01	-0,26	0,49	0,20	0,57	-0,17	0,61
	researchers	25	0,25	0,56	-0,97	0,37	0,78	0,03	0,17	0,70	0,45	0,25
	policy makers	25	0,97	0,16	0,96	0,29	0,97	0,22	-0,47	0,21	-0,24	0,53
	civil society	25	-0,24	0,51	-0,09	0,83	0,06	0,88	-0,12	0,74	0,17	0,63
SH participation Phase 4		35	-0,25	0,46	0,34	0,33	-0,17	0,64	-0,45	0,15	-0,22	0,44
Type of stake-holders	farmers	24	0,03	0,93	-0,11	0,80	-0,54	0,14	-0,70	0,02	-0,37	0,24
	advisors	24	-0,26	0,48	0,98	0,11	-0,48	0,19	-0,10	0,77	0,01	0,97
	researchers	24	0,42	0,26	0,44	0,34	0,84	0,01	0,13	0,73	0,26	0,48
	policy makers	24	0,99	0,02	0,98	0,16	0,99	0,04	-0,55	0,07	0,03	0,92
	civil society	24	-0,09	0,83	0,97	0,38	0,97	0,20	-0,29	0,45	-0,07	0,85
SH participation Phase 5		34	-0,10	0,79	-0,97	0,16	-0,97	0,11	-0,23	0,50	0,34	0,25
Type of stake-holders	farmers	26	0,18	0,62	-0,11	0,78	-0,98	0,04	0,27	0,43	0,07	0,84
	advisors	26	0,18	0,62	0,99	0,01	-0,18	0,62	0,43	0,18	0,13	0,68
	researchers	26	0,26	0,48	0,40	0,28	0,59	0,08	0,36	0,28	0,70	0,02
	policy makers	26	0,15	0,69	0,98	0,10	0,98	0,06	0,33	0,36	0,47	0,16
	civil society	26	0,97	0,12	0,97	0,17	0,97	0,12	0,98	0,06	0,99	0,03
SH participation Phase 6		36	0,29	0,34	-0,15	0,67	-0,24	0,49	0,05	0,85	0,56	0,03
Type of stake-holders	farmers	24	-0,16	0,69	-0,98	0,06	-0,99	0,03	-0,46	0,18	-0,54	0,11
	advisors	24	0,07	0,85	1,00	0,01	-0,11	0,77	0,24	0,48	0,10	0,77
	researchers	24	0,45	0,23	0,45	0,23	0,65	0,05	0,43	0,21	0,85	0,00
	policy makers	24	0,98	0,08	0,98	0,08	0,98	0,05	0,39	0,28	0,46	0,18
	civil society	24	0,97	0,15	0,97	0,15	0,98	0,10	0,98	0,05	0,99	0,03

Tetrachoric Correlation Coefficients and Probability > Chi Square under H_0: Rho=0. Statistically significant correlations are highlighted in blue for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

4.2.3.4 Implementation

Many authors pointed out the importance for ISA implementation of stakeholder participation from the start of the development (Diez and McIntosh, 2009; Röling, 2009; Binder *et al*., 2010; De Mey *et al*., 2011; Cerf, 2012; Sieber *et al*., 2012; Prost *et al*., 2012; Triste *et al*., 2014). This was the main objective for surveying stakeholder participation in all development stage. 0 shows the associations of ISA implementation as such and of different types of implementation with stakeholder participation in he consecutive phases of development.

For ISA implementation as such (assessment implemented, yes or no?) and stakeholder participation as such (yes/no), no significant associations were found. Participation by only a few stakeholder groups showed significant association with implementation as such (Table 16, 1st column):

- In phases 1 and 2 the participation of "other" stakeholders (who?) is strongly associated with implementation.
- Participation by extension workers and farmers in the early phases is negatively associated with implementation, which is counterintuitive and seems to contradict literature.

When differentiated by type of implementation though, farmer participation does look rather positively associated with implementation.

- For implementation on project basis the farmers' role is unclear, with farmer participation in phase 2 showing strong positive association with the implementation, but farmer participation in phases 3 and 4 showing strong negative associations.
- For commercial implementation, we find a strong positive association between the implementation and farmer participation in phase 5
- For certification farmer participation shows significant positive associations in phases 1, 4, 5 and 6.
- For ISA implementation by farmers, farmer participation in development is positively associated with implementation in phases 1, 2 and 5.

These positive effects confirm the positive correlation found between implementation by farmers and the number of phases in which stakeholders were involved (0.43, significant at 0.02 level).

Table 16. Associations of stakeholder (SH) participation in the consecutive phases of the ISA development with the implementation of the assessment

		N	Implementation		Implementation: project basis		Implementation: commercially		Implementation: certification		Implementation: used by farmers	
			Corre-lation	Pr > ChiSq	Corre-lation	Pr > ChiSq	Corre-lation	Pr > ChiSq	Corre-lation	Pr > ChiSq	Corre-lation	Pr > ChiSq
SH participation Phase 1		33	0,592	0,169	-0,935	0,453	0,948	0,353	0,944	0,384	-0,999	0,222
Type of stake-holders	farmers	30	-0,972	0,131	-0,363	0,304	0,364	0,249	0,577	0,067	0,572	0,051
	advisors	30	-0,996	0,020	-0,247	0,461	0,326	0,287	0,425	0,162	0,287	0,343
	researchers	30	-0,922	0,509	0,405	0,368	0,977	0,163	-0,228	0,613	-0,025	0,957
	policy makers	30	0,240	0,539	-0,277	0,406	0,435	0,143	0,337	0,272	0,290	0,330
	civil society	30	0,100	0,802	-0,175	0,603	-0,271	0,379	0,087	0,782	-0,071	0,816
SH participation Phase 2		33	-0,923	0,608	0,999	0,085	0,948	0,353	-0,985	0,120	0,999	0,245
Type of stake-holders	farmers	31	-0,985	0,029	-0,493	0,150	-0,046	0,883	0,228	0,470	0,596	0,032
	advisors	31	-0,990	0,016	0,078	0,824	-0,110	0,721	0,379	0,220	0,182	0,546
	researchers	31	-0,928	0,449	0,474	0,290	0,977	0,163	-0,283	0,530	0,025	0,957
	policy makers	31	0,409	0,246	-0,440	0,207	0,110	0,721	-0,120	0,707	0,283	0,342
	civil society	31	-0,125	0,728	0,013	0,970	-0,271	0,379	-0,072	0,824	-0,168	0,581
SH participation Phase 3		32	-0,968	0,145	0,498	0,129	0,153	0,645	0,000	1,000	0,676	0,023
Type of stake-holders	farmers	24	0,357	0,348	-0,989	0,084	0,000	1,000	0,000	1,000	0,489	0,155
	advisors	24	-0,228	0,562	-0,981	0,139	-0,263	0,457	0,150	0,688	-0,281	0,439
	researchers	24	0,339	0,445	0,737	0,113	-0,144	0,763	-0,299	0,531	0,220	0,646
	policy makers	24	0,964	0,278	-0,593	0,209	-0,113	0,796	0,061	0,892	0,982	0,091
	civil society	24	0,000	1,000	0,969	0,269	-0,418	0,276	-0,987	0,039	-0,105	0,788
SH participation Phase 4		32	0,138	0,734	0,107	0,756	0,126	0,703	0,393	0,247	0,380	0,224
Type of stake-holders	farmers	23	-0,152	0,744	-0,999	0,002	-0,016	0,965	0,587	0,070	0,137	0,696
	advisors	23	-0,990	0,076	-0,542	0,146	-0,137	0,696	0,180	0,604	-0,344	0,308
	researchers	23	0,430	0,353	0,619	0,108	-0,212	0,590	-0,212	0,590	-0,327	0,411
	policy makers	23	0,975	0,179	-0,212	0,590	0,304	0,380	0,304	0,380	0,447	0,187
	civil society	23	0,975	0,444	-0,292	0,521	-0,983	0,075	-0,080	0,853	-0,999	0,016
SH participation Phase 5		31	0,252	0,545	0,685	0,033	-0,078	0,826	-0,217	0,543	0,513	0,128
Type of stake-holders	farmers	24	-0,971	0,228	-0,973	0,203	0,997	0,004	0,990	0,018	0,634	0,046
	advisors	24	-0,984	0,107	0,000	1,000	0,299	0,374	0,339	0,335	0,146	0,664
	researchers	24	0,442	0,335	0,506	0,277	-0,240	0,537	-0,417	0,280	-0,291	0,463
	policy makers	24	0,971	0,228	0,973	0,203	0,461	0,170	0,389	0,272	0,285	0,415
	civil society	24	0,967	0,322	0,967	0,297	-0,342	0,370	-0,171	0,671	0,018	0,963
SH participation Phase 6		33	0,311	0,378	0,328	0,313	0,217	0,500	-0,148	0,646	0,709	0,013
Type of stake-holders	farmers	21	-0,971	0,232	-0,980	0,112	-0,522	0,140	-0,044	0,911	0,044	0,911
	advisors	21	-0,979	0,153	-0,149	0,735	0,127	0,728	0,200	0,596	-0,572	0,113
	researchers	21	0,494	0,294	0,394	0,403	0,988	0,055	-0,032	0,943	0,560	0,170
	policy makers	21	0,975	0,189	0,062	0,890	0,364	0,311	-0,083	0,829	0,484	0,198
	civil society	21	0,965	0,345	0,970	0,211	-0,326	0,425	-0,139	0,746	-0,351	0,385

Tetrachoric Correlation Coefficients and Probability > Chi Square under H_0: Rho=0. Statistically significant correlations are highlighted in blue for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

4.3 Cluster analysis

From the correlation analyses above it became clear that there are many associations between the multitude of variables generated by our survey. The obvious next step to clarify all these associations is cluster analysis, searching for clusters of ISA methods and even more important clusters of ISA characteristics. As over 1/3rd of the responses to the survey came in after our intended deadline of November 8th, the time left to analyse the responses before the end of the year became too short to accomplish more extensive in depth analysis. Such analysis is definitely recommended for further research on the survey results.

5 PRELIMINARY CONCLUSION

In Pilot Activity 1.1.1 an extensive inventory of sustainability frameworks, metrics and tools was compiled. From this inventory 51 integrated sustainability assessment (ISA) methods were selected for an in-depth survey. Furthermore, a comprehensive literature review was performed to find out how ISA methods have been characterised before. The most important characteristics were compiled and they provided the basis to develop a survey on the general ISA characteristics, stakeholder participation in the ISA development and the way indicators are used in ISA methods. The survey was sent out to the selected ISA methods' developers or users.

The survey was filled out by 37 respondents, making a 75 % response rate and resulted in an abundance of data on the ISA methods' characteristics. Descriptive analysis of the data revealed a large variation between the ISAs in the survey. They seldom represented the agricultural system in a strictly reductionist way, but ranged from attempting at an almost holistic representation with a (few) dozen(s) of indicators, to very elaborate, using hundreds of indicators to grasp the complexity of the system. Apart from farm development, a number of other purposes and often a combination of purposes was found; a wide range of end-users; a spectrum of data collection, processing and scoring methods to obtain indicators; and finally variate methods to combine indicators into an ISA. Stakeholder involvement in ISA development was found quite common practice, especially in the early phases, when the sustainability framework is defined and the indicators are selected.

Correlation analysis revealed many associations between the multitude of characteristics reported by the respondents. To date, however, the analysis was not sufficiently elaborated to be able to postulate decisive conclusions on how the compilation of ISA characteristics can help to unravel the question *how sustainability frameworks, metrics and tools and their implementation can be enhanced to futureproof agricultural decision making at multiple levels and multiple scales.* Further research is needed, starting with cluster analysis of ISA methods and their characteristics. It also seems interesting to expand the quantitative research with qualitative research, e.g. in-depth interviews with ISA developers, to grasp the full extent of reasoning behind ISA methods and the difficulties in their implementation.

In short, this first pilot activity managed to shed some light on the complexity of ISA methods and the variability in their characteristics, but further research is needed to reach conclusions on how they can be sufficiently enhanced to futureproof agricultural decision making.

References

This section contains general references mentioned in the main text body. References on specific sustainability assessment frameworks, metrics and tools may be found in Appendix 1.

Binder C.R., Feola G. Steinberger J. K. (2010) Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture. Environmental Impact Assessment Review 30: 71-81.

Bockstaller C., Gaillard G., Baumgartner D., Freiermuth-Knuchel R., Reinsch M., Brauner R., Unterseher E. (2006) Méthodes d'évaluation agri-environnementale des exploitations agricoles: Comparaison des méthodes INDIGO, KUL/USL, REPRO et SALCA, ITADA. INRA, Colmar, 112 p.

Bockstaller C., Guichard L., Keichinger O., Girardin P., Galan M.B., Gaillard G. (2009) Comparison of methods to assess the sustainability of agricultural systems. A review. Agronomy for Sustainable Development 29: 223-235.

Bockstaller C., Feschet P., Angevin F. (2015) Issues in evaluating sustainability of farming systems with indicators. Oilseeds and fats, Crops and Lipids 22 (1), http://dx.doi.org/10.1051/ocl/2014052.

Bonnet D.G., Price R.M. (2005) Inferential Methods for the Tetrachoric Correlation Coefficient. Journal of Educational and Behavioral Statistics 30 (2): 213-225.

Booysen (2002) An overview of composite indices of development. Social Indicators Research 59: 115-151.

Cerf M., Jeuffroy M., Prost L., Meynard J. (2012) Participatory design of agricultural decision support tools: taking account of the use situations. Agronomy for Sustainable Development 32: 899–910.

Chedzoy (2006) Phi-Coefficient. In: Encyclopedia of Statistical Sciences, John Wiley and Sons, doi/10.1002/0471667196.ess1960.pub2.

De Mey K., D'Haene K., Marchand F., Meul M., Lauwers L. (2011) Learning through stakeholder involvement in the implementation of MOTIFS: an integrated assessment model for sustainable farming in Flanders. International Journal of Agricultural Sustainability 9: 350-363.

de Ridder W., Turnpenny J., Nilsson M., von Raggamby A. (2007) A framework for tool selection and use in integrated assessment for sustainable development. Journal of Environmental Assessment Policy and Management 9: 423-441.

Diez E., McIntosh B.S. (2009) A review of the factors which influence the use and usefulness of information systems. Environmental Modelling & Software 24 (5):588–602.

Drewnowski J. (1972) Social indicators and welfare measurement: remarks on methodology. Journal of Development Studies 8: 77-90.

Ekström J. (2011) The Phi-coefficient, the Tetrachoric Correlation Coefficient, and the Pearson-Yule Debate. Department of Statistics Papers, University of California (UCLA), http://escholarship.org/uc/item/7qp4604r.

FAO (2013) SAFA Sustainability Assessment of Food and Agriculture systems. Guidelines version 3.0. Food and Agriculture Organization of the United Nations, Rome, 253 p.

Galan M.B., Peschard D., Boizard H. (2007) ISO 14001 at the farm level: Analysis of five methods for evaluating the environmental impact of agricultural practices. Journal of Environmental Management 82: 341-352.

Hansen J.W. (1996) Is agricultural sustainability a useful concept? Agricultural Systems 50: 117–143.

Hardi P., Zdan T. (1997) Assessing sustainable development: Principles in practice, International Institute for Sustainable Development, Winnipeg, Canada.

Hurni H., Osman-Elasha B. (Coordinating Lead Authors) (2009) Context, Conceptual Framework and Sustainability Indicators. In: IAASTD, Agriculture at a crossroads, Global Report. International Assessment of Agricultural Knowledge, Science and Technology for Development, Island Press, Washington: 1-56.

Kates R.W.; Parris T.M.; Leiserowitz A.A. (2005) What is sustainable development? Goals, indicators, values, and practice. Environment: Science and Policy for Sustainable Development 47 (3): 8-21.

López-Ridaura S., van Keulen H., van Ittersum M.K., Leffelaar P.A. (2005) Multi-scale methodological framework to derive criteria and indicators for sustainability evaluation of peasant natural resource management systems. Environment, Development and Sustainability 7: 51–69.

Marchand F., Debruyne L., Triste L., Gerrard C., Padel S., Lauwers L. (2014) Key characteristics for tool choice in indicator based sustainability assessment at farm level. Ecology and Society 19 (3): 46, http://dx.doi.org/10.5751/ES-06876-190346.

Payraudeau S., van der Werf H.M.G. (2005) Environmental impact assessment for a farming region: a review of methods. Agriculture, Ecosystems and Environment 107: 1-19.

Pope J., Bond A., Morrison-Saunders A., Retief F. (2013) Advancing the theory and practice of impact assessment: Setting the research agenda. Environmental Impact Assessment Review 41: 1-9.

Prost L., Cerf M., Jeuffroy M. (2012) Lack of consideration for end-users during the design of agronomic models. A review. Agronomy for Sustainable Development 32: 581–594.

Riley J. (2001) The indicator explosion: local needs and international challenges. Agriculture, Ecosystems and Environment 87: 119-120.

Röling N. (2009) Pathways for impact: scientists' different perspectives on agricultural innovation. International Journal for Agricultural Sustainability 7 (2): 83–94.

Schader C., Grenz J., Meier M.S., Stolze M. (2014) Scope and precision of sustainability assessment approaches to food systems. Ecology and Society 19 (3): 42, http://dx.doi.org/10.5751/ES-06866-190342.

Schindler J., Graef F., König H.J. (2015) Methods to assess farming sustainability in developing countries. A review. Agronomy for Sustainable Development 35: 1043-1057.

Sieber S., König H., Bezlepkina I., Reidsma P. (2012) Different levels of stakeholder participation for Sustainability Impact Assessment Tools - A comparative analysis of four research approaches. In: Seppelt R., Voinov A.A., Lange S., Bankamp V (Eds.) 2012 International Congress on Environmental Modelling and Software, Managing Resources of a Limited Planet, Sixth Biennial Meeting, Leipzig, Germany, http://www.iemss.org/sites/iemss2012/proceedings.html

Strange T.; Bayley A. (2008) Sustainable Development. Linking Economy, Society, Environment. Organisation for Economic Co-operation and Development (OECD), Paris, France.

WCED (1987) Our Common Future. Report of the World Commission on Environment and Development. United Nations, http://www.un-documents.net/our-common-future.pdf.

van der Werf H.M.G., Petit J. (2002) Evaluation of the environmental impact of agriculture at the farm level: a comparison and analysis of 12 indicator-based methods. Agriculture, Ecosystems and Environment 93: 131-145.

Wiek A., Binder C. (2005) Solution spaces for decision making – a sustainability assessment tool for city-regions. Environmental Impact Assessment Review 25: 589-608.

APPENDIX 1: INVENTORY OF SUSTAINABILITY FRAMEWORKS, METRICS AND TOOLS

- methods taken into the survey and for which response was received
- methods taken into the survey, but for which no response was received
- methods to be potentially included in a future, more exhaustive survey
- methods excluded from the survey, because they are not applicable to agriculture or do not assess multiple sustainability dimensions (see criteria section 2.2)
- methods not evaluated to date

Tool code	Tool's full name	Tool created on the initiative of	Origin	Year of develop ment	Agri-culture specific	Scope	Website	Literature
AgBalance	AgBalance	BASF	International	2012	yes	sustainability	http://www.agro.basf.com/agr/AP-Internet/en/content/sustainability/measuring_sustainability/agbalance/index	Schoeneboom *et* al. (2012), Saling *et al*. (2014)
BJCD	Caring Dairy Programme	Ben & Jerry's	International	2003	yes	sustainability	http://www.benjerry.com/caringdairy	
BRP	BedrijfsRoutePlanner / Farm Route Planner	Project (praktijknetwerk) based on 50 dairy farmers from the provinces Noord-Brabant, Fevoland, Gelderland and Overijssel. Tool built by CLM, supported by DLV	The Netherlands	2013	yes	economy, environment	http://www.duurzamemelkveehouderij.nl	
COSA Indicators	Committee on Sustainability Assessment Indicators (SEE)	The COSA consortium of 43 institutions.	International	2008	yes	sustainability	http://www.thecosa.org	
DEXiFruits	DEXiFruits	INRA, Ctifl, IFPC, AgroCampus Ouest	France	2015	yes	sustainability		Alaphilippe *et al*. (2013, 2015)
DEXiPM	DEXi Pest Management	French National Institute for Agricultural Research (INRA)	Europe	2009	yes	sustainability	http://www.inra.fr/en/Scientists-Students/Agricultural-systems/All-reports/Modelling-and-agrosystems/DEXiPM	Bohanec (2009), Messéan *et al*. (2010), Pelzer *et al*. (2012), Vasileiadis *et al*. (2013), PURE (2015)
EISA	Guideline for self assessment of European farming business	European Initiative for Sustainable Development in Agriculture (EISA)	Europe	2010	yes	sustainability	http://sustainable-agriculture.org	EISA (2011)
FAO-SAFA	Sustainability Assessment of Food	Food and Agriculture Organization of the United nations	International	2013	yes	sustainability	http://www.fao.org/nr/sustainability/sustainability-assessments-safa/en	FAO (2013, 2014)

	and Agriculture systems							
FoPIA	Framework for Participatory Impact Assessment	EU FP6 Integrated Project - Priority Area 1.1.6.3 "Global Change and Ecosystems"; SENSOR Project http://www.sensor-ip.org/	Europe	2010	yes	sustainability		Morris (2011), König (2010, 2012, 2013, 2015)
FtoM	The Fieldprint Calculator	Field to Market	USA	2011	yes	susainability	www.fieldtomarket.org	Field to Market (2012, 2014)
GlobalGAP	GLOBALG.A.P. Integrated Farm Assurance Standard	GLOBALG.A.P.	International	2001	yes	environment, socio	www.globalgap.org	GLOBALG.A.P. (2015a, b)
GRI	GRI G4 Sustainability Reporting Guidelines	Global Reporting Initiative	International	2013	no, but applica ble	sustainability	www.globalreporting.org	GRI (2013, 2015)
IDEA	Indicateurs de Durabilité des Exploitations Agricoles (IDEA) or Farm Sustainability Indicators (FSI)	The IDEA method stems from a request of the French Ministry of Agriculture. This tool was based on a group of researchers from multidisciplinary backgrounds, teachers and engineers technical institutes and coordinated first by Lionel Vilain and since 2009 by Frédéric Zahm (Researcher at Irstea research Center)	Europe	2008	yes	sustainability	http://www.idea.portea.fr/presentation.html	Vilain *et al*. (2008), Zahm *et al*. (2008)
indicIADes	Plateforme indicIADes	Institut d'Agriculture Durable	France		yes	sustainability	http://www.agridurable.fr/fr/les-indicateurs-de-durabilite	
INSPIA	INSPIA platform (European Index for Sustainable Productive Agriculture)	the INSPIA project	Europe	2014	yes	sustainability	http://www.agridurable.fr/fr/les-indicateurs-de-durabilite	
KSNL	Kriteriensystem Nachhaltige Landwirtschaft/Criteriasystem for sustainable agriculture	Thüringer Landesanstalt für Landwirtschaft (TLL)/Thuringian State Institute for Agriculture	Germany	2001	yes	sustainability	http://www.thueringen.de/th9/tll/agraroekologie/nachhaltigkeit	Breitschuh *et al*. (2008a,b), Zapf *et al*. (2009)

LEAF-Marque	LEAF Marque	LEAF (Linking Environment And Farming) started to develop the LEAF Marque in 2000. It is a farm assurance system showing that food has been grown sustainably with care for the environment.	Started in UK, now international in more than 33 countries	2000	yes	sustainability	http://www.leafuk.org/leaf/farmers/LEAFmarquecertification.eb	
LEAF-SFR	LEAF Sustainable Farming Review	LEAF (Linking Environment And Farming) started in 1991. In 1993, the first LEAF Audit was developed as a self-assessment resource for LEAF farmer members to support their implementation of Integrated Farm Management . In 2015, this was replaced by the LEAF Sustainable Farming Review which has the same objective.	International	1993	yes	sustainability	http://www.leafuk.org/leaf/farmers/LSFR.eb	
MESMIS	Marco para la Evaluación de Sistemas de Manejo de Recursos Naturales Incomprando Indicadores de Sustentabilidad / Framework for Assessing the Sustainability of Natural Ressource Management Systems	Interdisciplinary Group for Appropriate Rural Technology, GIRA A.C. (a Mexican NGO)	Mexico	1995	yes	sustainability	http://mesmis.gira.org.mx	Astier *et al.* (2000, 2011, 2012), Masera *et al.* (2000), López-Ridaura (2002), Speelman et al. (2007), Ripoll-Bosch *et al*. (2012)
MMF	Multi-scale sustainability evaluation framework	Grupo Interdisciplinario de Tecnologia rural Apropiada (GIRA A.C.) - Mexico AND Plant Production systems Group, Wageningen University - The Netherlands	International	2001	yes	sustainability		López-Ridaura (2005), López-Ridaura *et al.* (2005a,b), Delmotte (2013)
MOTIFS	Monitoring Tool for Integrated Farm Sustainability	Flemish Policy Research Centre for Sustainable Agriculture	Belgium	2006	yes	sustainability		Meul *et al*. (2008), Van Passel & Meul (2012)

NZSD	New Zealand Sustainability Dashboard	The project was mainly sparked by funding grant from New Zealand's Ministry of Business, Innovation & Employment in 2011. A pre-existing group of researchers and consultants (The Agriculture Research Group On Sustainability, ARGOS, www.argos.org.nz) were just completing a 10-year longitudinal study of Integrated Management and this call for proposals was the beginning of a next phase of research.	New Zealand	2011	yes	sustainability	www.nzdashboard.org.nz	Hunt *et al.* (2014)
OCIS-PGC	Public Goods Tool	The Organic Research Centre, Elm Farm, UK	UK	2010	yes	sustainability	http://www.organicresearchcentre.com/?go=Research%20and%20development&page=Resource%20use%20and%20sustainability&i=projects.php&p_id=20	Gerrard *et al.* (2011)
OECD-AEI	OECD Agri-environmental Indicators		International			environment	http://www.oecd.org/tad/sustainable-agriculture/agri-environmentalindicators.htm	
ORC-FAS	Farm Audit for Sustainability	Organic Research Centre	UK		yes	sustainability		Measures (2004)
OVALI	Outil d'éVALuation multicritère pour concevoir des systèmes de production avicoles Innovants / A methodology to assess the sustainability of the poultry supply chain (multicriteria assessment)	ITAVI (French poultry technical institute) and INRA (National Institute for Agronomic Research)	France	2014	yes	sustainability	http://www.itavi.asso.fr	
OXFAM	OXFAM Behind the Brands Scorecard	Oxfam	International	2013	incl. Ag	mainly social	http://www.behindthebrands.org/en/about	OXFAM (2014)

RISE	Response-Inducing Sustainability Evaluation	Bern University of Applied Sciences, upon requests from industry	International	2000	yes	sustainability	rise.hafl.bfh.ch; www.farmrise.ch	Häni *et al*. (2003, 2008) and many more: https://www.hafl.bfh.ch/fileadmin/docs/Forschung_Dienstleistungen/Agrarwissenschaften/Nachhaltigkeitsbeurteilung/RISE/Publikationen/Publikationen-RISE_en.pdf
SAFE	Framework for assessing sustainability levels in Belgian Agricultural systems	Consortium of 4 research institutes responding to a call of the Belgian Federal Science Policy office	Belgium	2005	yes	sustainability		Van Cauwenbergh et al. (2007)
SAI-FSA2.0	Farm Sustainability Assessment	Sustainable Agriculture Initiative	International	2013	yes	sustainability	http://www.saiplatform.org/fsa/fsa-2	Kuneman & Fellus (2014)
SAI-SPA	Sustainability Performance Assessment	Sustainable Agriculture Initiative (SAI) Platform	International	2014		environment	http://www.saiplatform.org/activities/alias/SPA	
SAN-SAS	Sustainable Agriculture Standard	Sustainable Agriculture Network	International	1997	yes	environment, socio	www.sanstandards.org; http://san.ag/web/our-standard/types-of-standards-and-policies/	SAN (2010)
ScalA	Scaling up assessment Tool ScalA	The German Acengy for International Collaboration GIZ in collaboration with the Food Agriculture Organization FAO	Germany	2005	yes	sustainability	http://project2.zalf.de/trans-sec/public/index	Sieber et al. (2015)
SEAMLESS	System for Environmental and Agricultural Modelling; Linking European Science and Soiety	FP6 integrated project SEAMLESS. Call was to develop and integrated framework for Integrated Assessment of Agricultural and environmental policies.	Europe	2009	yes	sustainability	http://www.seamless-ip.org	Van Ittersum et al. (2008); Ewert et al. (2009)
SMART	Sustainability Monitoring and Assessment RouTine (SMART)	Research Institute of Organic Agriculture (FiBL)	International	2012	Ag & food	sustainability	http://www.fibl.org/en/themes/smart-en.html	

SVA	Sustainable Value approach	This tool was originally created by Frank Figge and Tobias Hahn to measure corporate sustainability performance. Steven Van Passel (and several scholars) used and further developed the tool to assess farm sustainability.	Europe	2005	appli-cable	sustainability		Figge & Hahn (2005); Van Passel et al. (2009); Van Passel & Meul (2012; Ang & Van Passel (2010); Ang et al. (2011); Merante et al. (2015)
TOA-MD 5.0 model	Tradeoff Analysis Model for Multi-dimensional Impact Assessment	Funding from projects over 25 year period, including Rockefeller Foundation, USAID, UKAID, USDA-NIFA, US universities, CGIAR-funded projects.	USA	2011	yes	sustainability	http://tradeoffs.oregonstate.edu	Antle et al. (2015); Valdivia et al. (2015)
UNIL	Unilever Sustainable Agriculture Code	Unilever	Europe	2010	yes	sustainability	http://www.unilever.com/aboutus/supplier/sustainablesourcing	Smith et al. (2015)
Veldleeuwerik	Sustainability Profile	Foundation Skylark	The Netherlands	2014	yes	sustainability	http://veldleeuwerik.nl/en/	
AgEES	assessment based on environmental, economic and social perspectives	A number of NGOs, namely, UBINIG (Policy Research for Development Alternatives), Proshika, and CARE Bangladesh	Bangladesh	2004	yes	sustainability		Rasul & Thapa (2004)
DLG	DLG Certificate "Sustainable Agriculture – Fit for the Future" (2007)	Deutsche Landwirtschafts-Gesellschaft	Germany	2013	yes	sustainability	http://www.nachhaltige-landwirtschaft.info	Christen et al. (2013)
ENVIFOOD	Environmental Assessment of Food and Drink Protocol	European Food Sustainable Consumption and Production Round Table	Europe	2014	Ag & food	environment	http://www.food-scp.eu/node/29	Saouter et al. (2014)
MCDA	Multicriteria approach for measuring the sustainability of different poultry production systems		Italy	2012	yes	economic, social, meat quality and environmental		Castellini et al. (2012)
MAVT	Methodological approach based on Multiattribute Value Theory (MAVT)		Greece	2010	yes	sustainability		Dantsis et al. (2010)
MOP	Multi-objective parameters		Europe	1997	yes	Sustainability		Vereijken (1997)

OECD-GGI	OECD - Green Growth Indicators for Agriculture	An integral component of any green growth strategy is a highly-reliable set of measurement tools and indicators that would enable policy makers to evaluate how effective policies are, and to gauge the progress being achieved in shifting economic activity onto a greener path.	International		yes	econ-envir-soc?	http://www.oecd.org/tad/sustainable-agriculture/greengrowthforfoodagricultureandfisheries.htm	OECD (2013)
RAD-DD	Diagnostic de Durabilité du Réseau de l'Agriculture Durable		France	2001	yes	sustainabiliy	http://www.agriculture-durable.org	
SFP	Slow food presidia project		Italy		Ag & food	Sustainability + cultural	http://www.fondazioneslowfood.com/en/	Peano et al. (2014)
SF	Sustainability Flower	Soil & More (International organization of Ecology and Trade)	International		yes	sustainability	http://www.soilandmorefoundation.org/projects/sustainability-flower; https://prezi.com/pnwdar8jsd9d/the-sustainability-flower/	
SWNZ	Sustainable Winegrowing NZ		New Zealand		yes	Sustainability	www.nzwine.com/sustainability/sustainable-winegrowing-new-zealand	
UNGC-ISAP	Integrated Sustainable Agriculture Protocol	U.N. Global Compact Food and Agriculture Business Principles	International		yes	Sustainability	https://www.unglobalcompact.org/Issues/Environment/food_agriculture_business_principles.html; https://www.unglobalcompact.org/	
WFM	WFM - Responsibly grown	Whole Foods Market - Quality Standards	USA, Canada, UK		yes	Sustainability (economic?)	https://www.wholefoodsmarket.com/about-our-products/quality-standards	
DEFRA SDI	Sustainable Development Indicators / Agri-Environment Indicators	Department for Environment, Food & Rural Affairs	UK		?	Sustainability	Yearly SDI report on http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Agriculture+and+Environment#tab-sum-pub; AEI on https://www.gov.uk/government/statistical-data-sets/agri-environment-indicators	
DESIRE-DSS (WOCAT)	DESIRE-decision support systems	(participatory process of appraising and selecting sustainable land management measures)						Schwilch et al. (2009, 2012)

FSC	Forest Stewardship Council (Standard)		International		no	sustainability	www.fsc.org	
PIPA	Participatory impact pathways analysis (improvement of planning and evaluation of complex intervention in the water and food sectors)					Sustainability		Douthwaite et al, 2007; Alvarez et al, 2010
PROSA			Germany			Sustainability		Kloepffer (2008)
SIAT	Sustainability Impact Assessment Tool		Europe			Sustainability		
SD	Sustainability diagnosis	Familiarize farmers with sustainability on economy, environment and social aspects, and start a reflection on the way to improve weaknesses.	France			Sustainability		
Account Ability	AA1000 Stakeholder engagement standard		International		No	Governance	http://www.accountability.org	
ACO	Australian Certified Organic		Australia		Yes	Employment	www.aco.net.au	
AEI	Agro-ecological indicators: Nutrients (NP), pesticides, energy		France	1997	Yes	Environment		Bockstaller et al. (1997)
AEL	agricultural Environment Label: nutrients (NP), pesticides, energy			1995	Yes	Environment		De Vries et al. (1995, 1998)
AESA	Agro-ecological system attributes		Philippines	1997	Yes	Environment, economic		Dalsgaard et al. (1997)
AESIS	Agro-Environmental Sustainability Information System		Italy	2011	Yes	Environment		Pacini et al (2011)
AEI-EU	Agri-environmetal Indicators	Eurostat	Europe		yes	environment	http://ec.europa.eu/eurostat/web/agri-environmental-indicators/overview	
AGRO*ECO				2000	Yes	environment		Girardin et al. (2000)

APOIA-NovoRural	system for weighted environmental impact assessment of rural activities'		Brazil	2010	Yes	environment		Rodrigues et al. (2010).
ARBRE	Arbre de L'Exploitation Agricole Durable		France	2000	Yes	Social		Gasselin & Blanc (2010)
BIOBIO	Biodiversity Indicators for European Farming Systems		Europe	2012	Yes	Environment	http://www.biobio-indicator.org/	
CG	Conservation Grade		International		Yes	Biodiversity	www.conservationgrade.org	
CIS	compass index of sustainability			1997	No	Sustainability		Atkinson et al. (1997)
Cool Farm Tool	Cool Farm Alliance	originally developed by Unilever and researchers at the University of Aberdeen to help growers measure and understand on-farm greenhouse gas emissions.	UK		Yes	environment (carbon footprint of crop and livestock products)	http://www.coolfarmtool.org	
CSA	corporate sustainability assessment			2003	No		http://www.sustianability-index.com/	
CSPI	composite sustainability performance index			2007	No	Sustainability - governance-technical aspects		Singh et al. (2007)
Dairyman	Intermeg EU project		Europe		Yes	Economic, Environment	http://www.interregdairyman.eu/en/dairyman/Tools/Sustainability.htm	
DELTA				2010	Yes	Social		Parent et al. (2010)
DIALECTE				1994	Yes	Environment, economic	http://www.solagro.org	
DoAD	Declaration of Abu Dhabi	uses SAI Platform Farm Sustainability Assessment criteria (compilation of tools)	International		Yes	Sustainability	http://www.declaration-of-abu-dhabi.org/	
EALF	Ethical Account for Livestock Farms; Nutrients (NP), pesticides, energy			1999	Yes	Environment		Halberg (1999)
ECOFARM			USA	2000				
Eco-Index Methodology				2000				Chambers et al (2000)

EI	Ecolabel Index	collects and structures data on ecolabels globally, increasing transparency and helping buyers and sellers use them more effectively	International		No	Sustainability	http://www.ecolabelindex.com/	
EMA	Environmental Management for Agriculture (Nutrients (NPK), pesticides, energy)		UK		Yes	Environment		Lewis et al (1998)
EP	Ecopoints 1996 Ökopunkte Niederösterreich		Austria			Environment & landscape	http://www.oekopunkte.at/page.asp/-/6.htm	Mayrhofer et al. (1996).
EPI	Environmental Performance Index Framework		International		No	Environment	www.epi.yale.edu	
ESI	Environmental sustainability index			2001		Environment		Esty et al. (2005)
ETI	Ethical Trading Initiative Base Code		International		No	Social - Fair Trade	www.ethicaltrade.org	
FA	Food Alliance Standards		International		Yes	Environment, Social	www.foodalliance.org/standards	
FAO-LEAP	Livestock Environmental Assessment and Performance (LEAP) Partnership		International		Yes	LCA livestock	http://www.fao.org/partnerships/leap/en/	
Farm Smart	Farm Smart (self-assessment environmental footprint)				Yes	Environment	http://www.usdairy.com/farmsmart/Pages/Home.aspx	
Farm-Images	Interactive multi-goal agro-ecological generation and evaluation of systems		Uruguay		Yes	economic, environment		Dogliotti et al (2003, 2005, 2006)
FEAP	Farm Energy Audit Program			2009	Yes	Environment		
FESLM	Framework for Evaluating Sustainable Land Management			1994	Land management	Environment	https://www.mpl.ird.fr/crea/taller-colombia/FAO/AGLL/pdfdocs/feslm.pdf	

FHL	Herdbook System (1999); Nutrients (NPK), energy				Yes	Environment		FHL (1999a,b,c)
Ford of Europe's Product sustainability index					No	?	http://www.oecd.org/greengrowth/38761610.pdf	
FRC	Financial Reporting Council (U.K.)		International		No	Governance, Economic	https://www.frc.org.uk/	
FSI	Farmer Sustainability Index			1993				
FTI	Fair Trade International (FLO)		International		No	Social - Fair Trade	http://www.fairtrade.net/	
GA	Green Accounts for farms (Nutrients (NPK), pesticides, energy)			2000	Yes	Environment	www.lr.dk//groentregnskab	
GSCP	Global Social Compliance Programme (Reference Tools)		International		No	Environment, social	www.gscpnet.com	
Icsd	Composite sustainable development index (2005)				No	Sustainability		Krajnc & Glavic (2005)
IFAC	International Federation of Accountants		International		No	Sustainability	https://www.ifac.org/	
IFOAM SOAAN	Sustainable Organic Agriculture Action Network, Best Practice Guide	International Federation of Organic Agriculture Movements	International		Yes	Sustainability	www.ifoam.org	
IFSC	Illinois Farm Sustainability Calculator		USA		Yes	Environment, economic, how many people the farm can feed	https://www.ideals.illinois.edu/handle/2142/13458; http://web.extension.illinois.edu/dsi/projectdetail.cfm?NodeID=4035&type=Research	
IIRC	International Integrated Reporting		International		No	Sustainability	http://www.theiirc.org	

	Council						
ISAP	Indicator of Sustainable Agricultural Practice		2001	Yes	Environment		Rigby et al. (2001)
ISE	Bovespa Corporate sustainability index (2005)	Latin-America		No	Sustainability	http://isebvmf.com.br/; the value of ISE (http://www.bmfbovespa.com.br/indices/ResumoIndice.aspx?Indice=ISE&Idioma=en-us)	
ISO	ISO 14001	International		No	Environment	www.iso.org/iso/iso14000	
ISO	ISO 26000	International		No	Social reponsibility	http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=42546	
ITC	ITC Standards Map	International		No	Sustainability	http://www.standardsmap.org/	
KPMG	2000						
KUL/USL	Criteria for an Environmentally Compatible Agriculture (part of KSNL)		2000	Yes	Environment		Eckert et al. (2000)
La Via Campesina	International Peasant Movement (no framework,tools,…)	International		Yes	Sustainability	http://viacampesina.org/en/	
LCAA	LCA for agriculture (1997)	Europe		Yes	Environment		Audsley et al. (1997)
LCAE	LCA for Environmental farm management (1998)	Switserland		Yes	Environment		Rossier (1999)
Leclerc	Leclerc - Demarche Conso responsable	France		Yes	Sustainability (complete?)	http://www.consoresponsable.com/	
LInX	Life Cycle Index (2004)			No	Sustainability		Kahn (2004)
MDG	Millennium Development Goals	International		No	Sustainability	http://www.un.org/millenniumgoals/	
MEA	Millennium Ecosystem Assessment	USA		No	Sustainability		Millennium Ecosystem Assessment (2005)

MOST	Management of Social Transformations	International		No	Social	http://www.unesco.org/new/en/social-and-human-sciences/themes/most-programme/	
MP	Montreal Process Criteria and Indicators (forest management)	International		No	Sustainability	The Montréal Process 2009; http://www.montrealprocess.org/Resources/Criteria_and_Indicators/index.shtml	
Multistakeholders Roundtables	Multistakeholders Roundtables: RSPO, RTRS, BSCI, Bonsucro….	International					
NUANCES	Nutrient use in animal and cropping systems–efficiencies and scales framework			Yes	economic, environment		Giller et al (2006, 2011); Tittonell et al (2007, 2010)
OECD Gov	Organisation for Economic Co-operation & Development - Principles of good corporate governance.	International		No	Governance	http://www.oecd.org/corporate/ca/corporategovernanceprinciples/31557724.pdf	
Okobilanz	Life cycle assessment of agicultural systems and products			Yes	Environment	http://www.agroscope.admin.ch/oekobilanzen/01199/index.html?lang=en	
AVIBIO	method to assess the sustainability of the organic poultry industry *replaced by OVALI for all types of poultry production*	France		only organic			
OS	Operationalising Sustainability	The Netherlands	1997		environment, economy		Rossing et al (1997)
PROP'EAU	Prop'eau sable : projet-pilote pour la protection de la nappe aquifère du Bruxellien		2002	No			Lambert et al. (2002)

REPRO	Reproduction of Soil Fertility (Nutrients (NPK), pesticides, energy)		Germnay	2000	Yes	Environment	http://www.ecologyandsociety.org/vol19/iss3/art42/ES-2014-6866.pdf; http://www.landw.uni-halle.de/aoei/dy9701.htm	
SA8000S	Social Accountability 8000 Standard		International		No	Social	www.sa-intl.org/sa8000	
SALCA	Swiss Agricultural Life Cycle Assessment		Switzerland		Yes	Environment	http://www.ghgprotocol.org/Third-Party-Databases/SALCA; http://www.agroscope.admin.ch/oekobilanzen/01199/08185/index.html?lang=en	
SAN RA	SAN RA Chain of Custody – Rain Forest Alliance (complementary to SAN/SAS)		International		No	Sustainability	www.rainforest-alliance.org/.../san-ra-chain-of-custody-standard.pdf	
SBIA	Social and Biodiversity Impact Assessment (CCBA)		International		No	Environment, social	http://www.climate-standards.org/2011/11/22/social-and-biodiversity-impact-assessment-manual/	
SDI	The Sustainable Development Indicators (SDIs) are used to monitor the EU Sustainable Development Strategy (EU SDS) in a report published by Eurostat every two years. They are presented in ten themes.		Europe		No		http://ec.europa.eu/eurostat/web/sdi/indicators	
SEC	Sustainability of energy crops			1996				
SEEbalance	*Based on SEEbalance, they recently developed AgBalance, wich is specific for agriculture!*	BASF	Global	2005	No	sustainability		Saling et al. (2005)
SFI	Sustainable Forestry Initiative		USA		No	Sustainability	www.sfiprogram.org	
Social Carbon	Social Carbon		International		No	Sustainability	http://www.socialcarbon.org/	

	Methodology							
SSP	Sustainable Solution Space - Integrated sustainability assessment (2010)		Italy		Yes	Economic, Environment		Castoldi (2010a,b)
sustainability performance index		1994						
Sustainable corporate performance		2001						Vlek et al. (2001)
sustainable score card (DHV)								cramer et al. (2001)
Systemen voor de waardering van de duurzaamheid van veebedrijven		1999						
Telos-duurzaamheids balans	Sustainable integrated area development		Netherlands		No	Sustainability		
The Selwyn Stewardship Monitoring Scheme		1997	New Zealand		Yes	Environment, economic		Wratten et al., 1997, measuring sustainability in agricultural systems
TIM	Threat Indentification Model - agricultural land management sustainability (land-management planning)		Australia	2000	Yes	Environment?		Smith et al., 2000 - TIM: assessing the sustainability of agricultural land management
TSC	The Sustainable Consortium		International		Yes	Sustainability	http://www.sustainabilityconsortium.org/	

UN SDI	UN Sustainable Development Indicators		International		No	Sustainability	https://sustainabledevelopment.un.org/topics/indicators	
UNEP PRI	Principles for Responsible Investment (PRI)		International		No	Sustainability	http://www.unpri.org/	
UNEP LCA	UN Environment Programme (UNEP) - Life Cycle Analysis		International		No	Sustainability	www.lifecycleinitiative.org	
UNGC IFC	UN Global Compact/International Finance Corporation		International		No	Governance	UNGC/IFC, 2009	
UNHRC	UN Human Rights Council		International		No	Human Rights	http://www.ohchr.org/	
USL	Umweltsicherungssystem Landwirtschaft / System of environmentally compatible agriculture	offered by VDLUFA (association of German agriculture investigation and research)	Germany		Yes	Environment	http://www.interregdairyman.eu/en/dairyman/show/USL.htm	
Waitrose	The Waitrose Way		UK		Yes/No (sust. Of products)	Sustainability (complete?)	http://www.waitrose.com/home/inspiration/about_waitrose/the_waitrose_way.html	
Walmart	Ethical performance and socially responsible goals		USA		Yes/No (sust. Of products)	Sustainability (sustainablity index of TSC is used)	http://corporate.walmart.com/global-responsibility/environmental-sustainability	
WEF	New Vision for Agriculture	World Economic Forum	International		Yes	Sustainability?	http://www.weforum.org/projects/new-vision-agriculture	
WFMPA	whole-farm optimisation model		Greece	2010	Yes	economic-environmental (GHG) optimisation model		Sintori et al. (2010)

WWF Gold Standard	World Wildlife Fund Gold standard for Optimal Carbon Offsets	International	No	Sustainability	http://wwf.panda.org/what_we_do/how_we_work/businesses/climate/offsetting/gold_standard/
DIAGE	Fédération Régionale des Coopératives Agricoles de la Réunion	Réunion			www.frca-reunion.coop
DIALOGUE	Solagro				http://www.solagro.org
INDIGO	INRA Colmar	France			http://www7.inra.fr/indigo/fra/demo.html
Coles	Coles - Corporate responsibility and Sourcing	Australia	No	Sustainability	https://www.coles.com.au/corporate-responsibility; http://sustainability.wesfarmers.com.au/our-divisions/coles/

References

Alaphilippe *et al*. (2013) Application of DEXiPM® as a tool to co-design pome fruit systems towards sustainability. IOBC Bulletin 91: 531-535.

Alaphilippe *et al*. (2015) DEXiFruits: outil d'évaluation de la durabilité des systèmes de culture fruitière. INRA flyer, https://www.researchgate.net/publication/273120921_DEXiFruits_an_easy-to-use_tool_to_evaluate_the_sustainability_of_fruit_production_systems.

Alvarez S, Douthwaite B, Thiele G, Mackay R, Córdoba D, Tehelen K (2010) Participatory impact pathways analysis: a practical method for project planning and evaluation. Analyse participative des voies de l'impact: Une méthode pratique pour la planification et l'évaluation des projets 20(8):946–958. doi:10.1080/09614524.2010.513723.

Ang F., Van Passel S. (2010) The Sustainable Value approach: A clarifying and constructive comment. Ecological Economics 69: 2303–2306.

Ang F., Van Passel S., Mathijs E. (2011) An aggregate resource efficiency perspective on sustainability: A Sustainable Value application to the EU-15 countries. Ecological Economics 71: 99–110.

Antle J.M., Valdivia R.O., Boote K.J., Janssen S., Jones J.W., Porter C.H., Rosenzweig C., Ruane A.C., Thorburn P.J. (2015) AgMIP's Trans-disciplinary Agricultural Systems Approach to Regional Integrated Assessment of Climate Impact, Vulnerability and Adaptation. In Handbook of Climate Change and Agroecosystems: The Agricultural Model Intercomparison and Improvement Project (AgMIP) Integrated Crop and Economic Assessments. C. Rosenzweig and D. Hillel, eds. ICP Series on Climate Change Impacts, Adaptation, and Mitigation: Volume 3 Part 1. London: Imperial College Press, 27-44. doi: 10.1142/9781783265640_0002.

Astier M., García-Barrios L., Galván-Miyoshi Y., González-Esquivel C.E., Masera O.R. (2012) Assessing the sustainability of small farmer natural resource management systems. A critical analysis of the MESMIS program (1995-2010). Ecology and Society 17(3): 25, http://dx.doi.org/10.5751/ES-04910-170325.

Astier M., López-Ridaura S., Pérez Agis E., Masera O.R. (2000) El marco de evluación MESMIS y su aplicación en un Sistema agrícola campesino en la region Purhépecha, Mexico. Documento de Trabajo D35, Gruppo Interdisciplinario de Technología Rural Apropiada A.C., 19 p., http://mesmis.gira.org.mx/es/products.

Astier M., Speelman E.N., López-Ridaura S., Masera O.R., González-Esquivel C.E. (2011) Sustainability indicators, alternative strategies and trade-offs in peasant agroecosystems: analysing 15 case studies from Latin America. International Journal of Agricultural Sustainability 9(3): 409-422. http://dx.doi.org/10.1080/14735903.2011.583481

Atkinson G.D., Dubourg, R. Hamilton K., Munasighne M., Pearce, D.W., Young, C., 1997. Measuring sustainable development: macroeconomics and the environment. Edward elgar, cheltenham.

Audsley E., Alber S., Clift R., Cowell, S., Crettaz, P., Gaillard G., Hausheer J., Jolliett O., Kleijn R., Mortensen B., Pearce D., Roger E., Teulon H., Weidema B., van Zeijt H. (1997) Harmonisation of environmental life cycle assessment for agriculture, Final Report Concerted Action AIR3-CT94-2028. Silsoe Research Institute, Silsoe, UK.

Bockstaller C., Girardin P., van der Werf H.M.G. (1997) Use of agro-ecological indicators for the evaluation of farming systems. European Journal of Agronomy 7, 261–270.

Bohanec M. (2009) DEXi: program for multi-attribute decision making, Version 3.02. http://www-ai.ijs.si/MarkoBohanec/dexi.html.

Breitschuh G., Eckert H., Matthes I. (2008a) Kriteriensystem nachhaltige Landwirtschaft (KSNL). KTBL-Schrift 466, Darmstadt, Germany, 29 p., https://www.ktbl.de/fileadmin/produkte/leseprobe/11466excerpt.pdf.

Breitschuh G., Eckert H., Matthes I., Strümpfel J. (2008b) Nachhaltig wirtschaften mit KSNL. KTBL-Heft 78, Darmstadt, Germany, 9 p., https://www.ktbl.de/fileadmin/produkte/leseprobe/40078excerpt.pdf.

Castellini C., Boggia A., Cortina C., Dal Bosco A, Paolotti L., Novelli E.,Mugnai C. (2012) A multicriteria approach for measuring the sustainability of different poultry production systems. Journal of Cleaner Production 37: 192-201

Castoldi N., Bechini L. (2010a). Integrated sustainability assessment of cropping systems with agro-ecological and economic indicators in northern Italy. European Journal of Agronomy, 32(1), 59–72. doi:10.1016/j.eja.2009.02.003.

Castoldi N., Schmid A., Bechini L., Rebecca C. (2010b). Trade - off analysis for agro - ecological indicators : application of Sustainable Solution Space to maize cropping systems in northern Italy, (July), 850–860.

Chambers N., simmons C., Wackernagel M. (2000) sharing natures's interest ecological footprints as an indicator of sustainability (ch. 9, pg. 145 assessing impact of org.s and services)

Christen O., Deumelandt P., Edle K., Packeiser M., Reinicke F., von Daniels-Spangenberg H. (2013) Nachhaltiger Ackerbau – Effizienz steigern, Image pflegen, Ressourcen schonen. DLG-Merkblatt 369, Frankfurt-am-Main, Germany, 34 p., http://www.nachhaltige-landwirtschaft.info/fileadmin/downloads/pdf/dlg-merkblatt_369.pdf.

Cramer et al (2001) Duurzaam ondernemen: praktijkervaringen met een nulmeting. Nationaal initiatief duurzame ontwikkeling en DHV/adviesgroep duurzaam ondernemen, Leeuwarden en Amersfoort.

Dalsgaard J.P.T., Oficial R.T. (1998) Modeling and analyzing the agroecological performance of farms with ECOPATH. International Center for Living Aquatic Resources management, Makati City, Philippines, 54 p.

Dantsis T., Douma C., Giourga C., Loumou A., Polychronaki E. (2010). A methodological approach to assess and compare the sustainability level of agricultural plant production systems. Ecological Indicators, 10(2), 256–263. doi:10.1016/j.ecolind.2009.05.007

De Vries G.J.H. den Boer L. (1995) Evaluation of Milieukeur Arable Crops 1995. Centre for Agriculture and Environment, Utrecht, Netherlands.;

De Vries G.J.H., Middelkoop N., Pak G.A. (1998) The Ecological Sustainability of Horticulture and Agriculture. A Comparison of Organic and AgroMilieukeur. Centre for Agriculture and Environment, Utrecht, Netherlands.

Delmotte S., López-Ridaura S., Barbier J.-M., Wery J. (2013) Prospective and participatory integrated assessment of agricultural systems from farm to regional scales: Comparison of three modelling approaches. Journal of Environmental Management 129: 493-502.

Dogliotti S, Rossing WAH, Van Ittersum MK (2003) ROTAT, a tool for systematically generating crop rotations. European Journal Agronomy 19(2): 239–250.

Dogliotti S, van Ittersum MK, Rossing WAH (2005) A method for exploring sustainable development options at farm scale: a case study for vegetable farms in South Uruguay. Agricultural Systems 86(1): 29–51. doi:10.1016/j.agsy.2004.08.002

Dogliotti S, van Ittersum MK, Rossing WAH (2006) Influence of farm resource endowment on possibilities for sustainable development: a case study for vegetable farms in South Uruguay. Journal Environmenal Management 78(3): 305–315. doi:10.1016/j.jenvman.2005.04.025

Douthwaite B, Alvarez S, Cook S, Davies R, George P, Howell J, MacKay R, Rubiano J (2007) Participatory impact pathways analysis: a practical application of program theory in research-for-development. Canadian Journal of Program Evaluation 22(2): 127–159.

EISA (2011) Gaining excellence through increased awareness and everyday improvement: Guideline for self assessment of European farming businesses. Berlin, Germany, 23 p., http://sustainable-agriculture.org/integrated-farming.

Esty D.C., Levy M., Srebotnjak T., de Sherbinin A. (2005) Environmental Sustainability Index: Benchmarking National Environmental Stewardship. New Haven: Yale Center for Environmental Law & Policy.

Ewert F., Van Ittersum M.K., Bezlepkina I., Therond O., Andersen E., Belhouchette H., Bockstaller C., Brouwer F., Heckelei T., Janssen S., Knapen R., Kuiper M., Louhichi K., Alkan Olsson J., Turpin N., Wery J., Wien J.E., Wolf J. (2009) A methodology for enhanced flexibility of integrated assessment in agriculture. Environmental Science & Policy 12 (5): 546-561.

FAO (2013) Sustainability Assessment of Food and Agriculture systems. Indicators. Food and Agriculture Organization of the United Nations, Rome, 271 p., http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/SAFA_Indicators_final_19122013.pdf.

FAO (2014) Sustainability Assessment of Food and Agriculture systems. Guidelines version 3.0. Food and Agriculture Organization of the United Nations, Rome, 253 p., http://www.fao.org/3/a-i3957e.pdf.

FHL (1999a) Grundsatzliche Zusammenhange in der bewertung der Energi- und Narhstofbilanzen. Federation des Herdbooks Luxembourgeois, 5 pp.

FHL (1999b) Erlauterungen zu den Narhstoff- und Energiebilanzergebnissen eines Wirtschaftsjahres. Federation des Herdbooks Luxembourgeois, 7 pp.

FHL (1999c) Durchsnittsergebnis der Energi- und Narhstofbilanzen von 230 Betrieben des Jahres 1998. Federation des Herdbooks Luxembourgeois, 7 pp

Field to Market (2012 V2). Environmental and Socioeconomic Indicators for Measuring Outcomes of On-Farm Agricultural Production in the United States: Second Report, (Version 2). The Keystone Center, WashingtonDC, 164 p., https://www.fieldtomarket.org/report/national-2/PNT_SummaryReport_A17.pdf.

Field to Market (2014) Field to Market® Fieldprint® Calculator Algorithms Synopsis Documentation 2014, Version 1. The Keystone Center, WashingtonDC, 14 p.,

Figge F., Hahn T. (2005). The Cost of Sustainability Capital and the Creation of Sustainable Value by Companies. Journal of Industrial Ecology 9(4): 47–58.

Gasselin P., Le Blanc J. (2010). Assessing the sustainability of activity systems to support agricultural households ' projects, (July), 812–822. 9th European IFSA Symposium, 4-7 July 2010, Vienna (Austria)

Gerrard C., Smith V., Padel S., Pearce B., Hitchings R., Measures M., Cooper N. (2011) OCIS Public Goods Tool Development. Organic Research Centre Report. The Organic Research Centre, Berkshire, UK., 102 p.

Giller K.E., Rowe E.C., de Ridder N., van Keulen H. (2006) Resource use dynamics and interactions in the tropics: scaling up in space and

Giller K.E., Tittonell P., Rufino M.C., vanWijk M.T., Zingore S., Mapfumo P., Adjei-Nsiah S, Herrero M, Chikowo R, Corbeels M, Rowe EC, Baijukya F, Mwijage A, Smith J, Yeboah E, van der Burg WJ, Sanogo OM, Misiko M, de Ridder N, Karanja S, Kaizzi C, K'ungu J, Mwale M, Nwaga D, Pacini C, Vanlauwe B (2011) Communicating complexity: integrated assessment of trade-offs concerning soil fertility management within African farming systems to support innovation and development. Agricultural Systems 104(2): 191–203. doi:10.1016/j.agsy.2010.07.002

Girardin P, Bockstaller C, van der Werf H. (2000) Assessment of potential impacts of agricultural practices on the environment: the AGRO*ECO method. Environmental Impact Assessment Review 20: 227–39.

GLOBALG.A.P. (2015a) GLOBALG.A.P. General Regulations Part I – General Requirements. GLOBALG.A.P. c/o FoodPLUS gmbH, Cologne, Germany, 35 p., http://www.globalgap.org/export/sites/default/.content/.galleries/documents/150630_GG_GR_Part-I_V5-0_en.pdf.

GLOBALG.A.P. (2015a) Integrated Farm Assurance. All Farm Base – Crops Base – Fruit and Vegetables. GLOBALG.A.P., GLOBALG.A.P. c/o FoodPLUS gmbH, Cologne, Germany, 139 p., http://www.globalgap.org/export/sites/default/.content/.galleries/documents/150724_GG_IFA_CPCC_FV_V5-0_en.pdf.

GRI (2013) G4 Sustainability reporting guidelines. Reporting principles and standard disclosures. Global Reporting Initiative, Amsterdam, The Netherlands, 94 p., https://www.globalreporting.org/resourcelibrary/GRIG4-Part1-Reporting-Principles-and-Standard-Disclosures.pdf.

GRI (2015) Informing decisions, driving change. The role of data in a sustainable future. Global Reporting Initiative, Amsterdam, The Netherlands, 44 p., https://www.globalreporting.org/resourcelibrary/Informing-decisions,-driving-change-The-role-of-data-in-a-sustainable-future.pdf.

Halberg N. (1999) Indicators of resource use and environmental impact for use in a decision aid for Danish livestock farmers. Agriculture Ecosystems and Environmetn 76: 17–30.

Häni F, Braga F, Stämpfli A, Keller T, Ficher M, Porsche H. (2003) RISE: a tool for holistic sustainability assessment at the farm level. IAMA International Food and Agribusiness Management Review. 6(4):78-90, https://www.hafl.bfh.ch/fileadmin/docs/Forschung_Dienstleistungen/Agrarwissenschaften/Nachhaltigkeitsbeurteilung/RISE/Publikationen/Cancun_reviewed_26.4.05.pdf.

Häni F.J., Studer C., Thalmann C., Porsche H., Stämpfli A. (2008) RISE – Maβnahmenorientierte Nachhaltigkeitsanalyse landwirtschaftlicher Betriebe. KTBL-Schrift 467, Darmstadt, Germany, 91 p.

Helming K, Diehl K., Bach H., Dilly O., König B., Kuhlman T., Perez-Soba M., Sieber S., Tabbush P., Tscherning K., Wascher D., Wiggering H. (2011) Ex-ante impact assessment of land use change policies – A: analytical framework, Ecology and Society.16 (1): Art. 29, 1-23 Special Issue.

Hunt L., MacLeod C., Moller H., Reid J., Rosin C. (2014) Framework and indicators for 'The New Zealand Sustainability Dashboard': reflecting New Zealand's economic, social, environmental and management values. Version 1. NZ Sustainability Dashboard Research Report 13/09-v1, ARGOS, Christchurch, New Zealand, 178 p., http://www.nzdashboard.org.nz/uploads/2/3/7/3/23730248/13_09_v1_framework_and_kpis_synthesis_report.pdf.

Kahn F., Sadiq R., Veitch B. (2004) Life cycle iNdeX (LinX): a new indexing procedure for process and product design and decision-making. Journal of Cleaner Production 12: 59-76

König H.J., Podhora A., Zhen L., Helming K., Yan H., Du B., Wübbeke J., Wang C., Klinger J., Chen C., Uthes S. (2015) Knowledge brokerage for impact assessment of land use scenarios in inner Mongolia, China: extending and testing the FoPIA approach. Sustainability 7 (5): 5027–5049, doi:10.3390/su7055027.

König H.J., Schuler J., Suarma U., McNeill D., Imbernon J., Damayanti F., Aini S.D., Uthes S., Sartohadi J., Helming K., Morris J. (2010) Assessing the impact of land use policy on urban–rural sustainability using the FoPIA approach in Yogyakarta, Indonesia. Sustainability 2(7): 1991–2009.

König H.J., SghaierM., Schuler J., Abdeladhim M., Helming K., Tonneau J.P., Ounalli N., Imbernon J., Morris J., Wiggering H. (2012) Participatory impact assessment of soil and water conservation scenarios in Oum Zessar watershed, Tunisia. Environmental Management 50 (1): 153–165.

König H.J., Uthes S., Schuler J., Zhen L., Purushothaman S., Suarma U., Sghaier M., Makokha S., Helming K., Sieber S., Chen L., Brouwer F., Morris J., Wiggering H. (2013) Regional impact assessment of land use scenarios in developing countries using the FoPIA approach: findings from five case studies. Journal of Environmental Management 127: S56–S64, doi:10.1016/j.jenvman.2012.10.021.

Krajnc D., Glavic P. (2005) a model for integrated assessment of sustainable development. Resource conservation recycling 43, 189-208.

Kuneman G., Fellus E. (eds.) (2014) Sustainability Performance Assessment Version 2.0. Towards Consistent Measurement of Sustainability at Farm Level. CLM & SAI Platform, http://www.saiplatform.org/uploads/SPA%20Guidelines%202%200.pdf.

Lambert R., Van Bol V., Maljean J., Peeters A. (2002) Projet Prop'Eau

Lewis K.A., Bardon K.S. (1998) A computer-based informal environmental management system for agriculture. Environmental Modelling and Software 13: 123–137.

López-Ridaura S., Masera O., Astier M. (2002) Evaluating the sustainability of complex socio-environmental systems. The MESMIS framework. Ecological Indicators 2: 135-148

López-Ridaura S. (2005) Multi-scale sustainability Evaluation. A framework for the derivation and quantification of indicators for natural resource management systems. Tropical Resource Management Papers No. 68. Wageningen University, The Netherlands. 2002 p

López-Ridaura S., van Keulen H., van Ittersum M.K., Leffelaar P.A. (2005a) Multiscale sustainability evaluation. Quantifying indicators for different scales of analysis and their trade-offs using Linear Programming. International Journal of Sustainable Development & World Ecology 12: 81-97

López-Ridaura S., van Keulen H., van Ittersum M.K., Leffelaar P.A. (2005b) Multiscale methodological framework to derive indicators for sustainability evaluation of peasant natural resource management systems. Environment, Development and Sustainability 7: 51-69

Mayrhofer P., Steiner C., Gärber E., Gruber E. (1996) Regionalprogramm Ökopunkte Niederösterreich. Informationsheft. NÖ Landschaftsfonds, Wien, Austria.

Measures M. (2004): Farm Auditing for Sustainability. Harper Adams University College, UK:British Grassland Society.

Merante P., Van Passel S., Pacini C. (2015) Using agro-environmental models to design a sustainable benchmark for the sustainable value method. Agricultural Systems 136: 1–13.

Messéan A., Pelzer E., Bockstaller C., Lamine C., Angevin F. (2010) Outils d'évaluation et d'aide à la conception de stratégies innovantes de protection des grandes cultures. Innovations agronomiques 8: 69-81. http://www7.inra.fr/ciag/revue/volume_8_mai_2010.

Meul M., Van Passel S., Nevens F., Dessein J., Rogge E., Mulier A., Van Hauwermeiren A. (2008) MOTIFS: a monitoring tool for integrated farm sustainability. Agronomy for Sustainable Development 28(2): 321-332.

Morris J.B., Tassone V., De Groot R., Camilleri M., Moncada S. (2011) A Framework for Participatory Impact Assessment: involving stakeholders in European policy making, a case study of land use change in Malta. Ecology and Society 16(1): 12. http://www.ecologyandsociety.org/vol16/iss1/art12/

OECD (2013) OECD Compendium of Agri-environmental Indicators. Organisation for Economic Co-operation & Development, 190 p.

OECD (2014) Green Growth Indicators for Agriculture. A Preliminary Assessment. Organisation for Economic Co-operation and Development, Paris, 96 p.

OXFAM (2014) The Behind the Brands scorecard methodology. https://www.behindthebrands.org/~/media/Update%20Oct14/BtB%20Methodology%20document_final_Sept%202014.ashx.

Pacini G. C., Lazzerini G., Vazzana C. (2011) AESIS: a support tool for the evaluation of sustainability of agroecosystems. Example of applications to organic and integrated farming systems in Tuscany, Italy. Italian Journal of Agronomy, 6(1), 11–18. doi:10.4081/ija.2011.e3.

Parent D., Bélanger V., Vanasse A., Allard G., Pellerin D. (2010). Method for the evaluation of farm sustainability in Quebec , Canada : The social aspect, (July), 922–930.

Peano C., Migliorini P., Sottile F. (2014) A methodology for the sustainability assessment of agri-food systems: an application to the Slow Food Presidia project. Ecology and Society 19(4): 24. http://dx.doi.org/10.5751/ES-06972-190424

Pelzer E., Fortino G., Bockstaller C., Angevin F., Lamine C., Moonen C., Vasileiadis V., Guérin D., Guichard L., Reau R., Messéan A. (2012) Assessing innovative cropping systems with DEXiPM, a qualitative multi-criteria assessment tool derived from DEXi. Ecological indicators 18: 171-182.

PURE (2015) D1.7 Final versions of DEXiPM assessment tool. http://www.pure-ipm.eu/node/449.

Rasul G., Thapa G.B. (2004). Sustainability of ecological and conventional agricultural systems in Bangladesh: an assessment based on environmental, economic and social perspectives. Agricultural Systems, 79(3), 327–351. doi:10.1016/S0308-521X(03)00090-8

Rigby D., Woodhouse P., Young T., Burton M. (2001) Constructing a farm level indicator of sustainable agricultural practice. Ecological Economics, 39(3): 463–478. doi:10.1016/S0921-8009(01)00245-2

Ripoll-Bosch R., Díez-Unquera B., Ruiz R., Villalba D., Molina E., Joy M., Olaizola A., Bernués A. (2012) An integrated sustainability assessment of mediterranean sheep farms with different degrees of intensification.

Rodrigues G.S., Rodrigues I.A., Buschinelli C.C.D.A., De Barros I. (2010). Integrated farm sustainability assessment for the environmental management of rural activities. Environmental Impact Assessment Review 30(4): 229–239. doi:10.1016/j.eiar.2009.10.002

Rossier D. (1999) L'écobilan, outil de gestion écologique de l'exploitation agricole? Revue suisse Agric. 31 (4): 179–185.

Rossing W.A.H., Jansma J.E., de Ruijter F.J., Schans, J. (1997) Operationalising sustainability: exploring options for environmentally friendly flower bulb production systems. European Jornal Plant Pathology 103: 217–234.

Saling P., Schöneboom J., Künast C., Ufer A., Gipmans M., Frank M. (2014) Assessment of Biodiversity within the Holistic Sustainability Evaluation Method of AgBalance. 9th International Conference LCA of Food, San Francisco, USA, 8-10 October 2014.

SAN (2010) Sustainable Agriculture Standard. http://san.ag/web/wp-content/uploads/2014/11/SAN-S-1-4_Sustainable_Agriculture_Standard.pdf.

Saouter E., Bauer C, Blomsma C., De Camillis C, Lopez P., Lundquist L., Papagrigoraki A., Pennington D., Martin N., Schenker U., Vessia Ø. (2014) Moving from the ENVIFOOD Protocol to harmonized Product Category Rules and reference data: current and future challenges of the European Food Sustainable Consumption and Production Round Table. In: Schenck R., Huizenga D. (Eds.), 2014. Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector (LCA Food 2014), 8-10 October 2014, San Francisco, USA. ACLCA, Vashon, WA, USA.

Schoeneboom J., Saling P., Gipmans M. (2012) AgBalanceTM Technical Background Paper, BASF, Ludwigshafen, 37 p., http://www.agro.basf.com/agr/AP-Internet/en/function/conversions:/publish/upload/sustainability/AgBalance/307736_BASF_Tech-E_Paper-AgBalance.pdf.

Schwilch G, Bachmann F, Liniger HP (2009) Appraising and selecting conservation measures to mitigate desertification and land degradation based on stakeholder participation and global best practices. Land Degrad Dev 20(3): 308–326. doi:10.1002/ldr.920

Schwilch G, Bachmann F, Valente S, Coelho C, Moreira J, Laouina A, Chaker M, Aderghal M, Santos P, Reed MS (2012) A structured multi-stakeholder learning process for sustainable land management. Journal for Environmental Management 107: 52–63. doi:10.1016/j.jenvman.2012.04.023

Sieber S., Jha S., Amjath B., Bringe F., Crewett W., Uckert G., Polreich S., Hycenth Ndah T., Graef F., Mueller K. (2015) Integrated assessment of sustainable agricultural practices to enhance climate resilience in Morogoro, Tanzania. Regional Environmental Change, online first, Springer. http://link.springer.com/article/10.1007/s10113-015-0810-5

Sieber S., Müller M., Verweij P., Haraldsson H., Fricke K., Pacini C., Tscherning K., Helming K., Jansson T. (2008) Transfer into Decision Support: The Sustainability Impact Assessment Tool (SIAT). In: Helming, K., Tabbush, P., Perez-Soba, M., (Eds) 2008. Sustainability Impact Assessment of Land Use Changes. Springer, 107-128, ISBN 978-3-540-78647-4.

Singh R.K., Murty H.R., Gupta S.K., Dikshit A.K. (2007) development of composite sustainability performance index for steel industry. Ecological indicators 7, 565-588

Sintori A., Tsiboukas K., & Zervas G. (2010). Evaluating socio - economic and environmental sustainability of the sheep farming activity in Greece : A whole farm mathematical programming approach: 942–952.

Smith G. (ed.) (2015) Sustainable Agriculture Code 2015. Unilever, London, UK, 35 p., http://www.unilever.nl/Images/Unilever-Sustainable-Agriculture-Code_2015_tcm164-430985.pdf.

time. Agricultural Systems 88(1): 8–27. doi:10.1016/j.agsy.2005.06.016

Tittonell P., Corbeels M., van Wijk M.T., Giller K.E. (2010) FIELD—a summary simulation model of the soil–crop system to analyse long-term resource interactions and use efficiencies at farm scale. European Journal Agronomy 32(1): 10–21. doi:10.1016/j.eja.2009.05.008.

Tittonell P., van Wijk M.T., Rufino M.C., Vrugt J.A., Giller K.E. (2007) Analysing trade-offs in resource and labour allocation by smallholder farmers using inverse modelling techniques: a case-study from Kakamega district, western Kenya. Agricultural Systems 95(1–3): 76–95. doi:10.1016/j.agsy.2007.04.002

Valdivia R.O., Antle J.M., Rosenzweig C., Ruane A.C., Vervoot J., Ashfaq M., Hathie I., Tui S.H.-K., Mulwa R., Nhemachena C., Ponnusamy P., Rasnayaka H., Singh H. (2015) Representative agricultural pathways and scenarios for regional integrated assessment of climate change impacts, vulnerability, and adaptation. In Handbook of Climate Change and Agroecosystems: The Agricultural Model Intercomparison and Improvement Project (AgMIP) Integrated Crop and Economic Assessments. C. Rosenzweig, and D. Hillel, Eds., ICP Series on Climate Change Impacts, Adaptation, and Mitigation Vol. 3. Londoin: Imperial College Press, 101-156, doi:10.1142/9781783265640_0005.

Van Cauwenbergh N., Biala K., Bielders C., Brouckaert V., Franchois L., Garcia Cidad V., Hermy M., *et al.* (2007). SAFE—A hierarchical framework for assessing the sustainability of agricultural systems. Agriculture, Ecosystems & Environment, 120(2-4), 229–242, doi:10.1016/j.agee.2006.09.006

Van Ittersum, M.K., F. Ewert, T. Heckelei, J. Wery, J. Alkan Olsson, E. Andersen, I. Bezplepkina, F. Brouwer, M. Donatelli, G. Flichman, L. Olsson, A.E. Rizzoli, T. van der Wal, J.E. Wien and J. Wolf (2008) Integrated assessment of agricultural systems A component-based framework for the European Union (SEAMLESS). Agricultural Systems 96, 150-165.

Van Passel S, Meul M. (2012) Multilevel and multi-user sustainability assessment of farming systems. Environmental Impact Assessment Review 32 (1): 170–180.

Van Passel S., Meul M. (2012) Multilevel and multi-user sustainability assessment of farming systems. Environmental Impact Assessment Review 32: 170–180.

Van Passel S., Van Huylenbroeck G., Lauwers L., Mathijs E. (2009) Sustainable value assessment of farms using frontier efficiency benchmarks. Journal of Environmental Management 90: 3057–3069.

Vasileiadis V., Moonen A.C., Sattin M., Otto S., Pons X., Kudsk P., Veres A., Dorner Z., van der Weide R., Marraccini E., Pelzer E., Angevin F., Kiss J. (2013) Sustainability of European maize-based cropping systems: Economic, environmental and social assessment of current and proposed innovative IPM-based systems. European Journal of Agronomy 48: 1-11.

Vereijken P. (1997) A methodical way of prototyping integrated and ecological arable farming systems (I/EAFS) in interaction with pilot farms. European Journal of Agronomy 7: 235–250.

Vilain L., Boisset K., Girardin P., Guillaumin A., Mouchet C., Viaux P., Zahm F. (2008) La méthode IDEA – Indicateurs de durabilité des exploitations agricoles. 3ème édition actualise. Ed. Educagri, Dijon, 184 p.

Vlek et al. (2001) Towards a comprehensive model of sutainable corporate performance: three-dimensional modelling and pricatical measurement. Rijksuniversiteit Groningen: Groningen.

Zahm F., Viaux P., Vilain L., Girardin P., Mouchet C. (2008) Farm Sustainability Assessment using the IDEA Method. From the concept of farm sustainability to case studies on French farms. Sustainable Development 16: 271-281.

Zapf R., Schultheiß U., Oppermann R., Van den Weghe H., Döhler H., Doluschitz R. (2009) Bewertung der Nachhaltigkeit landwirtschaftlicher Betriebe. KTBL-Schrift 473, Darmstadt, Germany, 69 p.

APPENDIX 2: SURVEY OF SUSTAINABILITY FRAMEWORKS, METRICS AND TOOLS

OECD

TempAg

Why this survey?

Our aim is to collect information about on-going and recent work regarding sustainability assessment approaches (e.g. frameworks, tools, standards or others) in countries with temperate agriculture. The survey results will be used to answer the question “How can sustainability frameworks, metrics and tools and their implementation be enhanced to future-proof agricultural decision making at multiple levels on multiple scales?”.

Which information is collected?

The TempAg Inventory survey first asks for general information about the assessment you designed or used and your contact information. It continues with questions about this specific assessment, stakeholder participation and about the indicators within the assessment.

What is TempAg?

TempAg is an international research collaboration on sustainable temperate agriculture, supported by the OECD. It responds to emerging challenges such as sustainable intensification and resilience. In addition, it facilitates the development of methods for assessing the sustainability of agricultural practices. More information on TempAg: http://www.oecd.org/sti/sci-tech/tempag.htm.

General information

Tool code (see invitation mail) ________________

Tool's full name ____

Tool created on the initiative of ____

Origin

O International	O Africa	O Asia
O Europe	O North America	O South America
O Australia	O Bangladesh	O Belgium
O Canada	O France	O Germany
O Greece	O Italy	O Mexico
O New Zealand	O Switzerland	O The Netherlands
O UK	O USA	O Other ________________

Year of development ________________

Your contact details

Given name(s) ________________________________

Surname (family name) ________________________________

Institute/organisation ________________________________

e-mail ________________________________

Assessment related information

General characteristics of the assessment

Scope of the assessment: dimensions of sustainability considered

O economic	O environmental	O social
O cultural	O governance	O other ________________

Perspective on sustainability

O from societal point of view	O from the farm perspective	O other ________________

Primary purpose of the assessment: intended function

O reporting	O communication)	O farm development
O research	O certification	O other ________________

Level of assessment: spatial scale

O field	O farm	O industry
O chain	O national/regional	O landscape
O other ________________		

Sector scope: assessed farm or production type

O general	O dairy	O meat
O arable	O vegetables	O fruit
O other ________________		

System representation: Is the system represented in a reductionist (few indicators are used to assess the sustainability of a whole system) or holistic (reflects the complexity of a system by using many divers indicators) way?

O reductionistic	O holistic	O combination

Applying user: Who is carrying out the assessment?

O farmer	O extension worker	O civil servant
O policy maker	O researcher	O auditor
O others ________________		

End user: Who is using the results of the assessment?

O individual farmer	O farmer in discussion group	O extension workers
O researchers	O policy makers	O others ________________

Time needed for data collection

O < 2 h	O 2 - 4 h	O 1 day
O 2 days	O > 2 days	

Method used for data collection

O interview	O audit	O self-assessment
O other or specify ______________________________		

Aggregation: Are the indicator scores aggregated?

O yes	O no

Answer If Aggregation: Are the indicator scores aggregated? yes Is Selected
Which method is used for the aggregation? ____

Answer If Aggregation: Are the indicator scores aggregated? yes Is Selected
Level of aggregation: specify ____

Answer If Aggregation: Are the indicator scores aggregated? yes Is Selected

Is it a weighted aggregation?

- O yes
- O no

Answer If Is it a weighted aggregation? yes Is Selected

Which method is used for weighting? ____

Transparency: Regarding which topics are background documents or reports available?

- O content (aspects/facets measured)
- O purpose (goal for use of the results)
- O methodology of the assessment
- O indicator scoring
- O indicator aggregation
- O interpretation of the results
- O no background documents available

Implementation: Is the assessment being implemented?

- O yes
- O no

Answer If Implementation: Is the assessment being implemented? yes Is Selected

How is the assessment implemented?

- O project basis
- O used commercially
- O certification
- O used by farmers
- O other ________________

If you have any comments on the questions above, please enter them here.

____

Stakeholder participation

Have stakeholders been involved in the development or implementation of the assessment?

- O yes
- O no
- O I don't know

Answer If Have stakeholders been involved in developing the assessment? yes Is Selected

Phase 1: Preparatory phase: defining context, goal and challenges (system under consideration, scale of analysis, user groups)

Have stakeholders been involved in phase 1?

- O yes
- O no

Answer If Phase 1: Preparatory phase: defining context, goal and challenges... yes Is Selected

Q39 Which stakeholders were involved in phase 1?

- O farmers
- O extension workers
- O researchers
- O policy makers
- O civil society
- O other ________________

Answer If Phase 1: Preparatory phase: defining context, goal and challenges... yes Is Selected

Which type of participation was used in phase 1?

- O interviews
- O focus group(s)
- O other ________________

Answer If Have stakeholders been involved in developing the assessment? yes Is Selected

Phase 2: Indicator selection: choosing the appropriate sustainability indicators, taking decisions on including interactions between indicators and how to weight indicators

Have stakeholders been involved in phase 2?

- O yes
- O no

Answer If Phase 2: Indicator selection: choosing the appropriate... yes Is Selected

Q39 Which stakeholders were involved in phase 2?

- O farmers
- O extension workers
- O researchers
- O policy makers
- O civil society
- O other ________________

Answer If Phase 2: Indicator selection: choosing the appropriate... yes Is Selected

Which type of participation was used in phase 2?

- O interviews
- O focus group(s)
- O other ________________

Answer If Have stakeholders been involved in developing the assessment? yes Is Selected

Phase 3: Indicator measurement: quantification of indicators and processes (use of statistical data, surveys or categorized qualitative data)

Have stakeholders been involved in phase 3?

- O yes
- O no

Answer If Phase 3: Indicator measurement: quantification of indicators and... yes Is Selected

Q39 Which stakeholders were involved in phase 3?

- O farmers
- O extension workers
- O researchers
- O policy makers
- O civil society
- O other ________________

Answer If Phase 3: Indicator measurement: quantification of indicators and... yes Is Selected

Which type of participation was used in phase 3?

- O interviews
- O focus group(s)
- O other ________________

Answer If Have stakeholders been involved in developing the assessment? yes Is Selected

Phase 4: Aggregation of indicators (taking decisions on whether or not to aggregate indicators, to which extent and how)

Have stakeholders been involved in phase 4?

- O yes
- O no

Answer If Phase 4: Aggregation of indicators (taking decisions on... yes Is Selected

Q39 Which stakeholders were involved in phase 3?

- O farmers
- O extension workers
- O researchers
- O policy makers
- O civil society
- O other ________________

Answer If Phase 4: Aggregation of indicators (taking decisions on... yes Is Selected

Which type of participation was used in phase 3?

- O interviews
- O focus group(s)
- O other ________________

Answer If Have stakeholders been involved in developing the assessment? yes Is Selected

Phase 5: Applicability of the assessment results (the process of getting the generated knowledge ready for utilization in practice)

Have stakeholders been involved in phase 5?

- O yes
- O no

Answer If Phase 5: Applicability of the assessment results... yes Is Selected

Q39 Which stakeholders were involved in phase 3?

- O farmers
- O extension workers
- O researchers
- O policy makers
- O civil society
- O other ________________

Answer If Phase 5: Applicability of the assessment results... yes Is Selected
Which type of participation was used in phase 3?
- ○ interviews
- ○ focus group(s)
- ○ other ________________

Answer If Have stakeholders been involved in developing the assessment? yes Is Selected
Phase 6: Follow-up (reporting results, developing management advice, monitoring of indicators over time)

Have stakeholders been involved in phase 6?
- ○ yes
- ○ no

Answer If Phase 6: Follow-up (reporting results, developing management advice,... yes Is Selected
Q39 Which stakeholders were involved in phase 3?
- ○ farmers
- ○ extension workers
- ○ researchers
- ○ policy makers
- ○ civil society
- ○ other ________________

Answer If Phase 6: Follow-up (reporting results, developing management advice,... yes Is Selected
Which type of participation was used in phase 3?
- ○ interviews
- ○ focus group(s)
- ○ other ________________

Answer If Have stakeholders been involved in the development or implementation of the assessment? yes Is Selected
If you have any comments on the stakeholder participation during the assessment development or implementation, please enter them here.

____

Answer If Have stakeholders been involved in the development or implementation of the assessment? no Is Selected
Please motivate why stakeholders were not involved.

____

Answer If Have stakeholders been involved in the development or implementation of the assessment? I don't know Is Selected
Please motivate your previous answer.

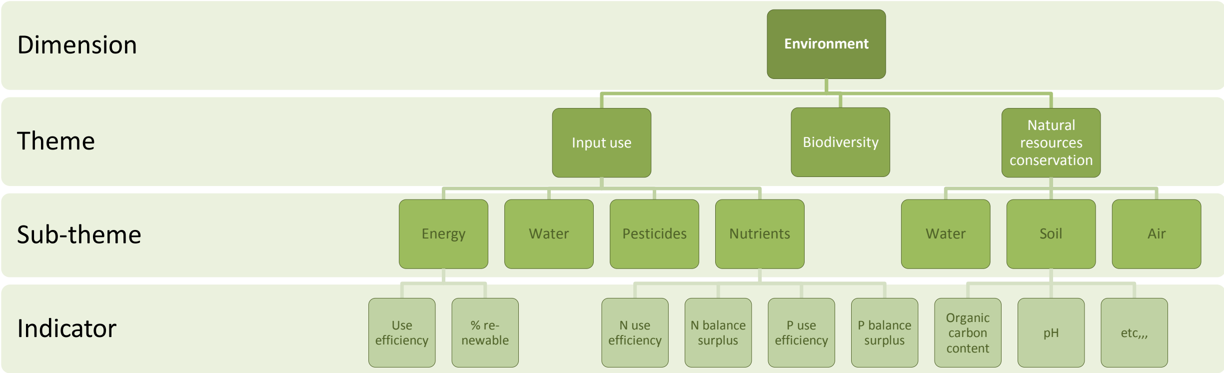
____

Indicator related information

Is information available regarding the indicators in the assessment (indicator types, data sources, scoring, etc.)?

○ yes ○ no ○ I don't know

Hierarchy in sustainability assessment system (Example drawn after Meul et al., 2008, MOTIFS, Agron. Sustain. Dev. 28: 321–332)



Show this section If Scope of the assessment: dimensions of sustainability considered: economic Is Selected

Economic dimension

Which type of economic indicators are used?

○ primarily quantitative ○ primarily qualitative ○ equally quantitative and qualitative

Level of data input

○ field ○ farm ○ farmer
○ product ○ region ○ other ________________

Data source

○ accountancy ○ farmer's knowledge ○ expert information
○ field practices ○ site practices ○ other ________________

Number of themes within the economic dimension ________________

Number of indicators within the economic dimension ________________

Reliability of data input for the economic indicators

○ yes, for all indicators within this dimension
○ yes, for most indicators
○ no, data input for many indicators is doubtful

Is the calculation method validated for the economic indicators?

○ yes ○ no

Answer If Is the calculation method validated for the economic indicators? Yes Is Selected

Validation type

____

Scoring system: please select how the economic indicators are scored and specify the methods used

○ benchmarks ⇨ specify ________________________________
○ expert based monitoring ⇨ specify ________________________________
○ scoring system from literature ⇨ specify ________________________________
○ other scoring system ⇨ specify ________________________________

Show this section If Scope of the assessment: dimensions of sustainability considered: environmental Is Selected

Environmental dimension

Which type of environmental indicators are used?

O primarily quantitative O primarily qualitative O equally quantitative and qualitative

Level of data input

O field O farm O farmer

O product O region O other ________________

Data source

O accountancy O farmer's knowledge O expert information

O field practices O site practices O other ________________

Number of themes within the environmental dimension ________________

Number of indicators within the environmental dimension ________________

Reliability of data input for the environmental indicators

O yes, for all indicators within this dimension

O yes, for most indicators

O no, data input for many indicators is doubtful

Is the calculation method validated for the environmental indicators?

O yes O no

Answer If Is the calculation method validated for the environmental indicators? Yes Is Selected

Validation type

____

Scoring system: please select how the environmental indicators are scored and specify the methods used

O benchmarks ⇨ specify ____

O expert based monitoring ⇨ specify ____

O scoring system from literature ⇨ specify ____

O other scoring system ⇨ specify ____

Show this section If Scope of the assessment: dimensions of sustainability considered: social Is Selected

Social dimension

Which type of social indicators are used?

O primarily quantitative O primarily qualitative O equally quantitative and qualitative

Level of data input

O field O farm O farmer

O product O region O other ________________

Data source

O accountancy O farmer's knowledge O expert information

O field practices O site practices O other ________________

Number of themes within the social dimension ________________

Number of indicators within the social dimension ________________

Reliability of data input for the social indicators
- O yes, for all indicators within this dimension
- O yes, for most indicators
- O no, data input for many indicators is doubtful

Is the calculation method validated for the social indicators?

O yes O no

Answer If Is the calculation method validated for the social indicators? Yes Is Selected
Validation type

____

Scoring system: please select how the social indicators are scored and specify the methods used
- O benchmarks ⇨ specify _______________________________________
- O expert based monitoring ⇨ specify _______________________________________
- O scoring system from literature ⇨ specify _______________________________________
- O other scoring system ⇨ specify _______________________________________

Show this section If Scope of the assessment: dimensions of sustainability considered: cultural Is Selected

Cultural dimension

Which type of cultural indicators are used?

O primarily quantitative O primarily qualitative O equally quantitative and qualitative

Level of data input

O field O farm O farmer
O product O region O other ________________

Data source

O accountancy O farmer's knowledge O expert information
O field practices O site practices O other ________________

Number of themes within the cultural dimension ________________

Number of indicators within the cultural dimension ________________

Reliability of data input for the cultural indicators
- O yes, for all indicators within this dimension
- O yes, for most indicators
- O no, data input for many indicators is doubtful

Is the calculation method validated for the cultural indicators?

O yes O no

Answer If Is the calculation method validated for the cultural indicators? Yes Is Selected
Validation type

____

Scoring system: please select how the cultural indicators are scored and specify the methods used
- O benchmarks ⇨ specify _______________________________________
- O expert based monitoring ⇨ specify _______________________________________
- O scoring system from literature ⇨ specify _______________________________________
- O other scoring system ⇨ specify _______________________________________

Show this section If Scope of the assessment: dimensions of sustainability considered: governance Is Selected

Governance dimension

Which type of governance indicators are used?

- O primarily quantitative
- O primarily qualitative
- O equally quantitative and qualitative

Level of data input

- O field
- O farm
- O farmer
- O product
- O region
- O other ________________

Data source

- O accountancy
- O farmer's knowledge
- O expert information
- O field practices
- O site practices
- O other ________________

Number of themes within the governance dimension ________________

Number of indicators within the governance dimension ________________

Reliability of data input for the governance indicators

- O yes, for all indicators within this dimension
- O yes, for most indicators
- O no, data input for many indicators is doubtful

Is the calculation method validated for the governance indicators?

- O yes
- O no

Answer If Is the calculation method validated for the governance indicators? Yes Is Selected

Validation type

____

Scoring system: please select how the governance indicators are scored and specify the methods used

- O benchmarks ⇨ specify ________________________________
- O expert based monitoring ⇨ specify ________________________________
- O scoring system from literature ⇨ specify ________________________________
- O other scoring system ⇨ specify ________________________________

Show this section If Scope of the assessment: dimensions of sustainability considered: other Is Selected

Other dimension

Which type of other indicators are used?

- O primarily quantitative
- O primarily qualitative
- O equally quantitative and qualitative

Level of data input

- O field
- O farm
- O farmer
- O product
- O region
- O other ________________

Data source

- O accountancy
- O farmer's knowledge
- O expert information
- O field practices
- O site practices
- O other ________________

Number of themes within the other dimension ________________

Number of indicators within the other dimension ________________

Reliability of data input for the other indicators
- O yes, for all indicators within this dimension
- O yes, for most indicators
- O no, data input for many indicators is doubtful

Is the calculation method validated for the other indicators?
O yes O no

Answer If Is the calculation method validated for the other indicators? Yes Is Selected
Validation type

____

Scoring system: please select how the other indicators are scored and specify the methods used
- O benchmarks ⇨ specify ________________________________
- O expert based monitoring ⇨ specify ________________________________
- O scoring system from literature ⇨ specify ________________________________
- O other scoring system ⇨ specify ________________________________

If you have any comments relating the indicators in the assessment, please enter them here.

____

If you would like to add references about the assessment, please enter them here. You can also send documents by replying to the invitation e-mail.

____

If you have any final remarks, please enter them here

____

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